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A Conceptual and Empirical Approach for Valuing Biodiversity: An Estimate of the Benefits of Plant and Wildlife Habitat Preservation in the Tensas River Basin.

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A CONCEPTUAL AND EMPIRICAL APPROACH FOR VALUING BIODIVERSITY: AN ESTIMATE OF THE BENEFITS OF PLANT AND WILDLIFE HABITAT PRESERVATION IN THE TENSAS RIVER BASIN

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Dedication

To my parents, Jack and Mary Ellen Isaacs

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Table of Contents

List of Tables

List of Figures

Abstract

This research estimated the passive use value of local species biodiversity in the Tensas River basin, a section of the Lower Mississippi River Valley. This research employed the contingent valuation method in eliciting willingness to pay for biodiversity conservation using the habitat needs of an umbrella species as a basis for valuation.

This study designed and implemented the Lower Mississippi Valley Plant and Wildlife Survey for primary data collection. The sample included 1,351 households drawn from a hunting permit lottery conducted by the Tensas River National Wildlife Refuge and 3,044 households drawn at random from Louisiana, Arkansas, and Mississippi. The survey distinguished between area users and nonusers to examine differences in valuation.

In a probit analysis of the nonuser group's responses to a dichotomous choice willingness to pay question, the value of a biodiversity conservation program was positively related to the respondent's education, income, concern over loss of natural habitat, knowledge of the decline in species' numbers, and attitudes concerning the fragility of nature. The value of biodiversity conservation was negatively correlated with the number of minors residing in the household. For the user sample, the value of biodiversity was positively related to the respondent's hunting skill, concern for the loss of wild habitat, and knowledge of the decline in species' numbers. Due to evidence of structural differences between the nonuser and user sample, this study adopts the recommendation of Silberman, Gerlowski, and Williams (1992) to exclude users from passive use valuation.

This research conducted multinomial logit analysis to examine the distinction between respondents in the nonuser sample who provided positive, negative, and uncertain responses. Positive responses were positively related to education, income, concern for the loss of natural habitat, knowledge of the decline in species' numbers, and attitudes concerning the fragility of nature and negatively related to the number of minors in the household. Negative responses were negatively related to income, knowledge of the term "biodiversity", attitudes regarding the fragility of nature, and anti-anthropocentric attitudes. Uncertain responses were negatively related to knowledge of the decline in species' numbers.

Chapter I

A Conceptual and Empirical Approach for Valuing Biodiversity

Introduction

The valuation of non-market goods estimates the value of commodities and amenities which do not satisfy some of the assumptions of neo-classical economics. Non-market valuation techniques have been employed to estimate the value of a number of natural resources, including endangered species. Most of the commodities for which non-market values have been estimated are well-defined, uni-dimensional amenities, such as the continued existence of a particular species at a particular location.

A shift in environmental policy suggests a need for valuation techniques capable of estimating the value of more complex, composite amenities. In response to policy needs, valuation methods may need to be expanded from measuring the value of a single species to measuring the value of a broader ecological unit. Recently, for example, as the scale of extinction has grown to threaten the ecosystems in which individual species exist (Norgaard, 1988; Wilson, 1988), attention has been directed to preserving habitats or ecosystems (U.S. Fish and Wildlife Service, 1994b). Efforts to value components of ecosystems broader than that of a single species may require adjustments to value estimation techniques.

The benefits of protecting ecosystems are many. Areas established for ecosystem protection can also be used for recreation and tourism. They provide educational and research opportunities as well as other consumptive and non-consumptive benefits.

Ecosystems perform important ecological processes such as soil formation, erosion control, and pollution abatement (Dixon and Sherman, 1990)(Figure 1.1). Included among ecosystem services is the provision of habitat for the multiple plant and animal species which populate the system. The variety of different plant and animal life has been labeled biological diversity or biodiversity, defined by the U.S. Fish and Wildlife Service as "the variety of life and its processes, including the variety of living organisms, the genetic differences among them, and the communities and ecosystems in which they occur" (U.S. Fish and Wildlife Service, 1994b, p.4).

The fundamental unit of biodiversity is usually perceived as the species, a unique organizational group usually defined by the ability of individual members of its population to breed with others of its kind. According to Mayr (1976), a species may be defined as:

> "a group of populations which replace each other geographically or ecologically and of which the neighboring ones intergrade or hybridize whenever they are in contact or are potentially capable of doing so (with one or more of the populations) in those cases where contact is prevented by geographical or ecological barriers." (p. 484)

This definition is appropriate for most organisms, but may exclude some asexual microorganisms (Hawksworth and Ritchie, 1993). Approximately 1.4 million (Wilson, 1988) to 1.7 million (Hammond, 1992) different species have been studied and catalogued (Wilson, 1988). Most of the species on the planet have not been scientifically identified and categorized. The estimated global scope of biodiversity ranges from five to thirty million different species. The majority of the animal species diversity is expected to be among invertebrates, notably arthropods and nematodes. Fungi are also

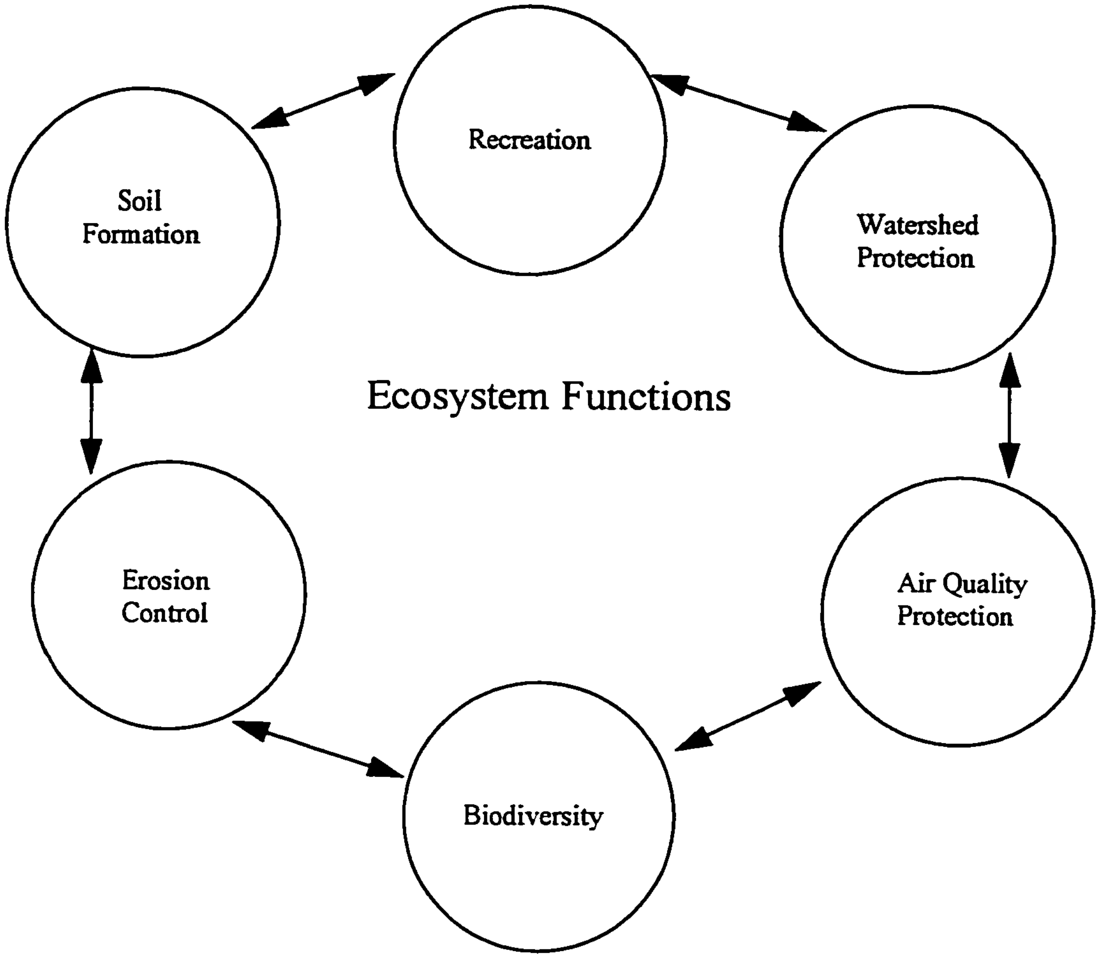

Figure 1.1 Partial Listing of Ecosystem Functions
Source: Dixon and Sherman, 1990

a diverse biological category, containing estimates of 1.5 to 2.7 million species (Hawksworth and Ritchie, 1993).

Because of the large number of different species, the study of biological diversity can be facilitated by constructing divisions or categories of species based upon organizational or functional criteria. The multitude of individual species can be organized into larger categorical components (Huston, 1994). Categories include biological organization, geographical measures, or ecological function.

According to the level of biological organization, biodiversity may be described in three different fundamental ways: genetic diversity, species diversity, and ecosystem diversity. Genetic diversity refers to the differences in the genetic codes among individual plants and animals. Species diversity refers to differences among species populations which are important to the sustained health of plant and animal species. Ecosystem diversity refers "to the variety of habitats, biotic communities, and ecological processes in the biosphere as well as the diversity within ecosystems" (Pearce and Moran, 1994, p. 5).

A fourth level of biodiversity, taxonomic diversity, refers to the diversity of organisms at levels of the phylogenetic hierarchy above the species level: kingdoms, phyla, classes, orders, and families (Groombridge, 1992; Hawksworth and Ritchie, 1993). This definition of biological diversity has been applied in comparisons of biotic resources among ecosystems (Heywood and Watson, 1995) and across geological or evolutionary periods (Gould, 1989; Ward, 1994; Wilson, 1992).

The study of biodiversity can be delineated by geographical scale. General patterns indicate that greater levels of diversity generally are found in lower latitudes, warmer climates, lower altitudes, more mountainous areas, and moderately disturbed landscapes. Larger regions are usually more diverse than smaller areas (Schulter and Rickelfs, 1993; Huston, 1994).

Variation in speciation can be broadly divided into local and global patterns. Although the conditions which affect the former differ from those which affect the latter, local and global measures of diversity are related by the degree of migration of species among different localities. Local diversity or α-diversity is the variation of species occurring within a specific habitat or ecosystem. The measure of inter-ecosystem migration, or β-diversity, refers to the turnover of species between habitats or localities. Total diversity, or γ-diversity, refers to the variety of species within a larger area. This measure is the product of α-diversity and β-diversity ($\alpha \cdot \beta = \gamma$) (Schulter and Rickelfs, 1993).

Biodiversity can also be categorized according to the function performed by species or groups of species within an ecosystem. Structural species, for example, are those which create or form structure for the environment such as trees, corals, kelp,and sessile animals. Interstitial species are those which exist within the structure provided by the structural species, including arthropods, understory herbivory, birds and other mammals. The diversity of the two general types of organisms may be influenced by different factors and processes (Huston, 1994).

Human Influence on Biodiversity Loss

As the attention of biology, ecology, and other sciences has been directed to the complex biological and ecological interactions between species and habitat, it has become apparent that certain processes are now diminishing biological diversity at a local and global scale, mainly due to human activities. Although the extinction of species is a natural part of the ecological and evolutionary processes (Gould, 1989; Wilson, 1992), human activities have contributed to the disappearance of species through hunting, land use, and other consumptive practices for at least the last ten thousand years (Swanson, 1995a). During the last four centuries, 386 animals and 645 plant species have been recorded extinct (Heywood and Watson, 1995). More recently human activities are believed to have accelerated the rate of species extinction beyond that expected under typical evolutionary processes (Holling, *et al.*, 1995). According to some studies, the current rate of extinction is proceeding at a pace one-thousand to ten-thousand times the historical rate. Within the next century, twenty-five to fifty percent of the total species may become extinct (Pearce and Moran, 1994).

The depletion of biodiversity results from the conversion of natural resources from the provision of natural assets to more productive artificial forms. Exploiting the benefits of specialization in the production of certain species (Groombridge, 1992; Krautkraemer, 1995), human choices in landscape transformation have expanded the range of heavily utilized species with negative effects on the unselected species (Swanson, 1995b). Conversion of land to agriculture, the leading source of natural habitat loss (Barbier and Rauscher, 1995), represents a transformation of land from the production of one form, i.e., *Spartina* grass, to the production of another, i.e., rice, believed to provide more utility to humans (Groombridge, 1992; Swanson, 1995b). Not all human landscape transformations have negative implications for biodiversity. Species diversity can actually be enhanced by moderate human disturbances although the level of biodiversity declines at higher rates of utilization (Huston, 1994; Middleton and Merriam, 1985; Leidy and Fielder, 1985).

The process of the conversion of biotic resources may not lead to an efficient amount of biological diversity because the person who may benefit from the conversion is unlikely to consider the full costs. Because biodiversity is a collective or global good, the costs of its conversion are globally distributed (Groombridge, 1992; Perrings, *et al.*, 1995a; Barrett, 1995). Preservation of biodiversity may be the collectively, but not individually, optimal strategy (Hanemann, 1988), because the social costs of biodiversity loss may be ignored by the individuals imposing the landscape changes (Barbier and Rauscher, 1995).

A lack of information regarding the nature of ecological functions contributes further to depletion of biological diversity (Turner, *et al.*, 1995). Due to the limited knowledge of the consequences of changes in the composition of species, the depletion of biodiversity often results from the interruption of the complex interaction between and among different species of plants and animals. Human actions in hunting, harvesting, and land use may disrupt predator-prey relationships (Luckayanov, Cooper, and Harwell, 1995; McLaren and Peterson, 1994), parasite-host and parasitoid-host relationships (Roland and Taylor, 1997), and other instances of interspecific interaction. The introduction of exotic species has had additional frequently unanticipated on biodiversity (Smith, Daily, and Ehrlich, 1995; Jenkins, 1996). Externalities associated with production, including pollution, sedimentation, and the disruption of water flow (Fong and Harwell, 1994; Thibodeau and Nickerson, 1985; Vidrine, 1996; Costanza, Kemp, and Boynton, 1995) have also led to the diminution of biological diversity.

Costs of Biodiversity Loss

Among the negative externalities emanating from biodiversity depletion is the potential loss of ecological services which biological diversity supports or provides (Turner, *et al.*, 1995). A reduction in biodiversity may reduce the ability of an ecosystem to react to an adverse shock by eliminating individual species or collections of species which fill certain vital niches needed to respond to the stimulus. The resulting decline in the ecosystem could have further negative repercussions for its constituent species. If an ecosystem is not fundamentally unstable, a reduction in the degree of biodiversity may not be so damaging. As the elimination of a particular species may leave vacant certain ecological niches, other species could adapt and perform those important duties in their stead (Flint, 1993; Wilson, 1988).

Most of the other ecosystem functions appear to be relatively more stable than biological diversity. Because the interplay of species within ecosystems is a nonlinear function, the disappearance of a species may not necessarily lead to instability. The extinction or extirpation of numerous species on a larger scale may reduce the resiliency of an ecosystem, the capacity to reach a stable equilibrium after an adverse shock (Perrings, 1995; Pimm, 1984; Holling, *et al.*, 1995).

The reduction of biodiversity could also have some negative commercial impacts. The depletion of biodiversity may have a negative effect on productive activities including grazing (Perrings and Walker, 1995), timber (Barbier and Rauscher, 1995), and commercial fishing (Brown and Roughgarten, 1995; Constanza, Kemp, and Boynton, 1995).

A reduction in biologically diverse resources may reduce the quality of outdoor recreational activity experiences. Birdwatching, for example, is positively associated with the variety of species encountered. The reduction in the number of neotropical bird species may reduce the value of the birding experience (Hvengaard, Butler, and Krystofial, 1989; Clayton and Mendelsohn, 1992; Stotz, *et al.*, 1996). On the other hand, the depletion of biodiversity may be positively associated with other forms of outdoor recreation. Some popular hunting species, like the white-tailed deer, may respond well to some types of ecosystem degradation associated with farming and suburbanization, although this may lower the diversity of species overall (Waller, 1996).

Another cost of the loss of biodiversity may result from a reduction in existence value. As there is an existence value cost resulting from the extinction of a species, there may be some loss in existence value resulting from the diminution of biodiversity. In short, there may be some cost, a reduction in human utility, simply from knowing of the depletion of biodiversity (Rowthorn and Brown, 1995).

Biodiversity and Environmental Policy

Despite the apparent costs associated with habitat conversion, current institutions may not be able to address the issue of biological diversity loss (Krautkraemer, 1995).

This has called for a reform in the structure of institutions and for a change in the incentive structure regarding natural habitat preservation. Due to the nature of natural habitat and biological diversity as a public or global good, policies for the conservation of biological diverse resources have been organized at the national and international level (Swanson, 1995a).

Biodiversity has been the recent focus of national and international attention. Members of the international community voiced concern for the preservation of biodiversity in the Stockholm Conference Declaration of 1972, the U.N. Charter for Nature of 1982 (Miller, *et al.*, 1985), and the World Conservation Strategy of 1980 (Thibodeau and Field, 1984). In 1987, the influential Report of the World Commission on the Environment and Development, the "Brundtland Report," featured an entire chapter on biodiversity conservation (Troyer, 1990). The United Nations Conference on Environment and Development (the "Earth Summit") in 1992, the largest diplomatic gathering ever held, produced the Biodiversity Convention, a treaty detailing the needs for conservation of biological diversity. These suggest a recognition of the desire for international and national policies designed to ameliorate the erosion of biological diversity (Valentine, 1991; Soroos, 1994).

The U.S. Department of State Biological Diversity Conference of 1982 foreshadowed a shift in U.S. environmental policies (Miller, *et al.*, 1985). By the early 1990's, the U. S. Fish and Wildlife Service redirected its habitat management focus from an emphasis on single endangered species preservation toward the maintenance of ecosystems (U.S. Fish and Wildlife Service, 1994b). This change was implemented due to perceptions of the inefficacy of the preservation policy based on the protection of endangered species. A broader approach focusing on ecosystems is seen as more effective in preserving habitat and protecting a variety of ecosystem functions, including biodiversity.

Proponents of the ecosystem approach point to some of its strengths relative to the endangered species preservation approach. Single-species conservation efforts often do not adequately address the habitat needs of other species in the ecosystem. The ecosystem approach may be used to preserve habitat for species endangered or threatened from a ecological standpoint but lacking the legal status guaranteeing protection under the Endangered Species Act of 1973 ("Endangered Species Act", 1995). Single-species preservation, by managing specifically for the continuance of one species, for example the snow goose, may actually require habitat modification to the detriment of the other species of plants and animals in the ecosystem (Beattie, 1996; Waller, 1996; Rockewell, Abraham, and Jefferies, 1997).

Ecosystem management policies may incorporate a focus on a single species in its preservation goals. Certain species, because of peculiar ecosystem functions or habitat requirements, can be used to measure the status of the ecosystem at large. Three categories of species which may be used as an index in biodiversity habitat preservation include bioindicator, keystone species, and umbrella species.

Bioindicators are species sensitive to changes in environmental quality. Examples include species of snails (Waller, 1996), freshwater mollusks (Vidrine, 1996), and seagrasses (Fong and Harwell, 1994). Keystone species are those which exercise a disproportionate effect on other species or ecosystem function (Hawksworth and Ritchie, 1993). These species may play a central role through predation, e.g., wolves (McLaren and Peterson, 1994), otters (Wilson, 1992), and grizzly bears; habitat structure manipulation, e.g., prairie dogs (Beattie, 1996); or other processes.

Umbrella species have habitat requirements can be used to measure ecosystem protection. Managers believe that by protecting such species, they can protect the ecosystem as a whole (Patlis, 1996). The northern spotted owl is one prominent example of an endangered species used as an umbrella species for its old growth forest habitat in the United States Pacific Northwest (Rubin, Hefland, and Loomis, 1991).

Although the Endangered Species Act (the Act) forbids the use of economic cost analysis in designating protected species, the implementation of the Act has incorporated economic costs and benefits into the decision-making process at other levels. The designation of critical habitat, the design of recovery plans, and the consultation of federal agencies with the U. S. Fish and Wildlife Service are points in the decision-making process in which economic considerations may be entertained (Snape, 1996b). Policy may benefit from an economic valuation of biodiversity.

Economic Valuation of Biodiversity

Efforts to place an economic value on a natural resource like an ecosystem involves an intellectual concession to anthropocentricism, the belief that the interests and concerns of *Homo sapiens* take preference over those of other species (Mazzotta and Kline, 1995). A non-anthropocentric or biocentric view would not place mankind above any other species but rather in a system involving other forms of life. Such a view would argue that each species holds an intrinsic value beyond man's ability to add or subtract. Efforts at valuing a species in economic terms alone may therefore be inadequate (Daly and Cobb, 1994; Norton, 1988).

As a positive science, neoclassical economics studies the value that humans place on resources, not the intrinsic value they may have. Value is assigned to a good in terms of the utility a human individual derives from it. Whatever the limitations such a position may place upon the supposed worth of the analysis, it does nevertheless permit a positive analysis less encumbered by normative value judgements (Hanemann, 1988).

Neoclassical economics does not seek to explain the origin of utility. A person may base utility on whatever grounds an individual holds appropriate. Economic theory posits only that the bases of utility are rational and consistent. The concept of value is firmly rooted in the theory of individual utility. Due to the presence of scarcity, everything, including environmental amenities, has an opportunity cost, the next best alternative commodity declined in order to possess a certain good. Utility analysis is the construct by which economists analyze the value of goods and amenities.

In neoclassical economic theory, the value of a commodity or consumer good is captured in the price of the item. A problem arises for many commodities, such as environmental amenities, including ecosystems, for which ordinary markets do not exist. Because such goods do not exist in discrete, exclusive units to which a price can be affixed, markets for these may be absent or incomplete (Randall, 1988). Economic theory maintains that even in the absence of ordinary market mechanisms, such goods are nevertheless "purchased" in terms of opportunity cost. The value of an ecosystem then is in part reflected in the value of the consumer goods and economic development sacrificed in order to preserve the natural habitat.

Previous research states that the total economic value of an environmental amenity consists of several component values. In general, the value of natural resources can be divided into two main categories: use and non-use values (Stevens, *et al.*, 1991). Non-use values are also known as passive use values (Arrow, *et al.*, 1993; *State of Ohio v. Department of the Interior*, (D.C. Cir. 1989); Randall, 1997).

Use values can be divided into consumptive value, non-consumptive value and option value. Consumptive value pertains to extractive use of a resource, such as farming, mining, hunting, or developing. Non-consumptive value is derived from non-extractive use, such as hiking, canoeing, bird-watching, or tourism (Dufus and Dearden, 1990; Rockel and Kealy, 1991; Mangun, O'Leary, and Mangun, 1992). Option value is that value placed on a currently unused resource which one may prize as a reserve potentially to be used in the future as the need may arise (Weisbrod, 1964; Barrick and Beazley, 1990; Greenley, Walsh, and Young, 1981).

Passive use values consist of bequest value and existence value. Bequest value is the value of preserving a resource for future generations. Existence value is derived from the satisfaction of knowing that a particular resource, such as a national park, a national monument, or an endangered species, survives even if one never intends to use it personally (Krutilla, 1967; Stevens, *et al.*, 1991; Bishop and Welsh, 1992).

Non-Market Valuation Methods

A number of methods to estimate values are based on individual observed or hypothetical behavior. Non-market valuation methods include the hedonic methods, indirect market methods, and the direct valuation methods. Hedonic methods (Freeman, 1992) and indirect valuation methods, such as the travel cost method (Hotelling *in* Smith, 1990; Walsh, Johnson, and McKean, 1989; Desvouges, *et al.*, 1993) are unable to account for existence or option values (Bishop and Heberlein, 1979; Randall, *et al.*, 1983; Seller, Stoll, and Chavas, 1985; Smith, Desvouges, and Fisher, 1986; Hoehn, 1991; Randall, 1993).

Previous research suggests that contingent valuation is the theoretically appropriate method for valuing environmental amenities because it can estimate existence, option, and bequest values, or passive use values. This method is based on direct responses to a hypothetical market for the environmental commodity (Smith, Desvouges, and Fisher, 1986; Walsh, Johnson, and McKean, 1989.) In this direct valuation method, carefully worded questions elicit the value an individual places on a non-market amenity. These values are used to compute estimates for the value of the resource.

Contingent valuation methods are divided into two categories based upon the type of value they seek to estimate: willingness to pay and willingness to accept compensation (or willingness to sell.) The first category estimates each respondent's willingness to pay for the preservation of a resource and supplies an equivalent (surplus) welfare measure. The second category elicits the willingness to accept compensation for the loss of a resource and estimates compensating (surplus) welfare measures (Rowe, D'Arge, and Brookshire, 1980; Hanemann, 1984; Seller, Stoll, and Chavas, 1985; Gregory, 1986; Cameron, 1988; Cameron, 1991).

Contingent valuation methods have been applied to a variety of environmental assets. A number of studies have estimated the costs and benefits of protecting a particular site from environmental degradation (Thayer, 1980), aesthetic damage (Bishop, Heberlein, and Kealy, 1985; Boyle and Bishop, 1988; Bergstrom Stoll, and Randall, 1985; Bergstrom and Stoll, 1987), and pollution (Randall, Ives, and Eastman, 1974; Rowe, D'Arge, and Brookshire, 1980; Hoehn, 1991).

Contingent valuation methods have been used to estimate the value of individual species for both consumptive and non-consumptive recreational purposes (Bishop, Heberlein, and Kealy, 1983). These methods have also been applied to a variety of endangered species in a number of different locations (Brown and Goldstein, 1984), including whooping cranes (Bowker and Stoll, 1988); humpback whales (Samples, Dixon, and Gowan, 1986); Atlantic salmon, coyotes, bald eagles, and wild turkeys (Stevens, *et al.*, 1994); and the striped shiner, an obscure fish species in Wisconsin (Boyle and Bishop , 1987).

Problem Statement

The complexity of biodiversity complicates estimation of passive use value. Because the contribution of biodiversity to and the role played by individual species in the health and stability of an ecosystem may currently be unknown, the uncertainty surrounding the ecological aspects of biodiversity and the uncertain benefits of preserving it may require special procedural and theoretical adjustments to current valuation methods in order to elicit passive use values. Research into the area of biodiversity is made necessary by revisions in public policy which increasingly require valuation of more complex commodities than those included in previous research. The purpose of this research, therefore, is to provide a conceptual framework and empirical example for the adjustments in non-market valuation methods needed to estimate the passive use value of biodiversity within an ecosystem.

Justification

This research employs nonmarket valuation techniques to estimate the value of the complex ecological amenity, biodiversity. Nonmarket valuation techniques have previously been used to estimate the value of endangered species affected by natural resource use. The need to use nonmarket valuation to value the more comprehensive environmental good, biodiversity, has been made necessary by revisions in federal resource preservation policies.

Following research in the natural sciences regarding ecosystem functions, policy makers have increasingly shifted the focus of preservation efforts from specific species to the wider entity of ecosystems (Schaumberger, *et al.*, 1992; U.S. Fish and Wildlife Service, 1994a). As environmental policy broadens its management goals, there is a need for economic valuation of a composite commodity, biodiversity, broader than commodities previously valued in non-market economic research, species. The valuation of biodiversity involves the development of the concept of biological diversity so individuals can understand the commodity and assign a value to it. This research involves the framing of biological diversity in nonmarket valuation.

Objectives

The general objective of this research is to contribute to the conceptual and procedural development of non-market valuation in order to estimate the passive use value of biodiversity within an ecosystem. The specific objectives of this research include:

1. to identify and review literature in the field of valuation, relevant to ecosystem valuation;
2. to develop a conceptual model of valuation of passive use values related to biodiversity;
3. to test empirically the conceptualized valuation model, and
4. to suggest possible policy implications based upon the empirical analysis.

Procedures

Objective 1

This research conducts a complete and comprehensive literature review of economic and ecological sources to develop the appropriate theory and devise the proper techniques to estimate the value of an ecosystem. This research discusses the contribution of economics to the study of biodiversity, and reviews literature from other fields addressing ecological issues, especially endangered species, extinction, and biodiversity. Because this research assesses an economic valuation of an ecological amenity, the literature review integrates biological, ecological and other scientific sources. This consists of previous research addressing the biological and ecological aspects of biodiversity in general, as well as individual plant and animal species that may be found within the ecosystem being studied.

This research examines the microeconomic foundations of the theory of valuation. In order to gain an understanding of the economic parameters being measured, this research reviews literature regarding the theoretical aspects of Hicksian compensated value and equivalent value, the parameters which most valuation studies estimate.

The literature review also encompasses previous economic literature in the area of valuation. Various methods of valuation are examined in order to assess the theoretically and practically appropriate valuation techniques. This includes previous research on valuation of a variety of non-market goods. Particular attention will be paid to prior research regarding endangered species valuation, as this research employs single species valuation techniques to include the more complex commodity of biodiversity.

Objective 2

Through accomplishment of objective two, this research applies concepts and techniques discussed in previous research in the field of non-market valuation to conceptualize an appropriate model for valuing biodiversity. This research proposes that non-market valuation methods can be used to estimate the value of biodiversity, a complex environmental amenity.

Contingent valuation techniques measure the change in individual welfare resulting from a change in the use of resources for which competitive markets do not exist. The measure of change is frequently defined in terms of change in consumer surplus, the residual difference between the amount an individual would be willing to pay for a commodity and the price he actually paid it. Four measures of the change in consumer welfare proposed by Hicks (1943), compensating variation, compensating surplus, equivalent variation, and equivalent surplus, are reviewed.

This research develops a conceptual model which is used to estimate the passive use value of biodiversity. The measurement of passive use values encompasses estimates of existence and bequest values. This research examines the estimation of a composite good in a manner that is both ecologically and economically meaningful.

Objective 3

This research empirically estimates the passive use value of biodiversity in the Tensas River basin, a section of the Lower Mississippi Valley in northeast Louisiana by employing non-market valuation methods. This research elicited the passive use value of biodiversity existing within a section of the Lower Mississippi River Valley ecosystem in northeast Louisiana. The Lower Mississippi Valley is a geographical area stretching from Cairo, Illinois, to New Orleans, Louisiana and encompassing twenty-six million acres in seven states. Its contains prime bottomland hardwoods and wetlands which are considered to be among the most important wildlife habitat areas in the United States (U.S. Department of the Interior, 1988). The Tensas River valley in northeast Louisiana is one of the remaining contiguous sections of bottomland hardwoods forests of significant size. It is considered an important natural resource by the United States Fish and Wildlife Service, the Natural Resource Conservation Service, the Nature Conservancy, and other environmental agencies.

The selection of non-market valuation methods was based on previous research on the valuation of endangered species, habitat, and other environmental amenities and the conceptual model developed in objective two. Previous literature regarding the contingent valuation method in particular was consulted in the process of applying the method for valuation of biodiversity.

In order to examine the influence of residential proximity on passive use value the sample of this research includes households both included in and outside the Tensas River basin ecosystem from Louisiana and two states contiguous, Arkansas and Mississippi. The sample was drawn from two sources distinguished by use of the Tensas River basin. One sample was drawn from a hunting license lottery system conducted by the Tensas River National Wildlife Refuge. The other, intended to measure the passive use value of nonusers, was drawn at random from telephone directories in the states in the survey sample, Louisiana, Arkansas, and Mississippi.

Objective 4

The results of this research are both conceptual and empirical. While the conceptual results may be of more interest to the economic research community, they have implications for the public management sector. The conceptual and empirical results suggest further research directions, also of interest to research and management. The results of this research can be used to suggest possible policy implications for state agencies, the extension research community, the U.S. Fish and Wildlife Service, the National Biological Survey, and other government agencies.

Outline of Dissertation

The dissertation includes five chapters. Chapter one presented the research problem, objectives, and procedures. It has also introduced the complexity of the biodiversity valuation process. Chapter two reviews the non-market valuation literature and develops a conceptual model. Chapter three presents the development of the survey instrument and data collection procedures and survey descriptive statistics. The empirical analysis is presented in chapter four. Chapter five provides a summary and conclusions.

Chapter II

Conceptual Model of Biodiversity Valuation

Introduction

The uncertainty and multiattribute properties of biodiversity necessitate the modification of previous non-market valuation methods. Non-market valuation methods have been applied to estimate the benefits or costs of the provision of a variety of environmental resources. Previous research has been directed toward eliciting the value of specifically designated environmental commodities, i.e., goose-hunting permits (Bishop and Heberlein, 1979; Bishop, Heberlein, and Kealy, 1983), recreational activities (Walsh, Johnson, and McKean, 1989); farmland preservation (Bergstrom and Stoll, 1987), and the protection of endangered species (Brookshire, *et al.*, 1983; Samples, Dixon, and Gowan, 1986; Stevens, *et al.*, 1990; Hagen, Vincent, and Welle, 1992). Measurements of the value of air quality (Randall, Ives, and Eastman, 1974; Rowe, d'Arge, and Brookshire, 1980) and water quality (Greenley, Walsh, and Young, 1981; Smith, Desvouges, and Fisher, 1986; Desvouges, Smith, and Fisher, 1987) have used various objective standards to describe the qualitative level of the natural amenity in question. Non-market valuations of environmental amenities under uncertainty elicit the value of a particular amenity for which the future demand or the future supply may vary (Smith, 1983).

This research will estimate the value of species biodiversity at a local geographical scale or the α-diversity within the ecosystem (Pearce and Moran, 1994). Species biodiversity is the definition most appropriate to current governmental policy goals within the study area, the Tensas River basin (U.S. Fish and Wildlife Service, 1994). The policy focus on the role of biodiversity in the maintenance of ecosystem stability as distinguished from a policy focus on its value as a store of genetic material has important implications for the cost of biodiversity loss (Perrings, 1995).

The following section expands upon the concept of value to include passive use value. It explores the literature relevant to the passive use valuation of biodiversity. Based upon the discussion of previous research, a conceptual model of biodiversity valuation is proposed.

Component Measures of Value

Because a single commodity may be valued according to a variety of purposes, an individual may be motivated by a number of components in the valuation of a single commodity. The value of an amenity may be divided into component values, with total value as a function of use values and non-use values (Figure 2.1).

Use values are the values of any use of a natural resource. Use value includes consumptive use and non-consumptive use of an amenity. The former refers to the extractive use of a resource such as the taking of fish, game, timber, or minerals. The latter refers to uses such as hiking and bird-watching which do not involve the extraction of natural resources (Dufus and Dearden, 1990).

Non-use values arise from individuals who may derive utility from a commodity which they do not directly use or consume. Individuals may gain satisfaction by not consuming a commodity for a variety of motives including concern for others' use and the simple knowledge that a good exists.

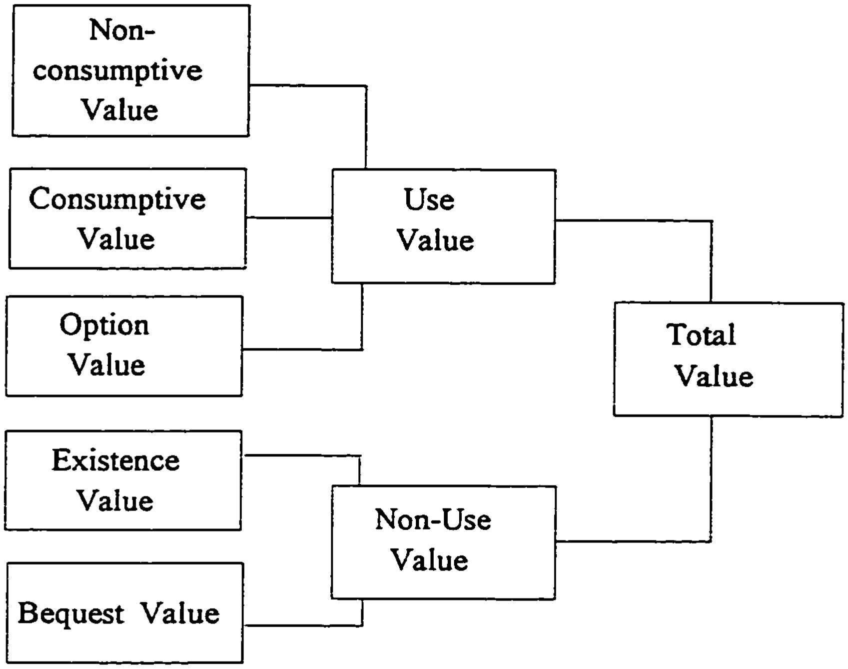

Figure 2.1 Total Economic Value of Biodiversity
Source: Turner, 1991; Weisbrod, 1964; Krutilla, 1967.

Many economists have come to believe that non-use values should be included in the assessment of benefit-cost analysis (Smith, 1987). Non-use values have often been divided into component values, including existence value, bequest value, option value, and quasi-option value (Randall, 1991).

Option value is the value of retaining an option to consume an asset in the future (Schmalansee, 1972; Stevens, *et al.*, 1991). A similar concept, quasi-option value, is the expected value of information gained by postponing consumption (Arrow and Fisher, 1974; McConnell, 1983). The appropriateness of including particular components, namely option value and quasi-option value, as non-use values has not been conclusively settled within the literature (Randall and Kriesel, 1990).

Existence value is the value assigned by individuals to an asset independent of its use. The second oldest of the non-user values, existence value was conceptualized by Krutilla (1967) who suggested that individuals may hold a value for amenities which they may never actually use. The origin of existence value is the utility that individuals derive simply from knowing that a particular amenity exists (Stevens, *et al.*, 1991; Madriaga and McConnell, 1987).

The last component of non-use value is bequest value which arises from the utility an individual derives from the utility of other persons, for example, heirs or descendants. Bequest value is motivated by a desire to preserve an asset for use by future generations (McConnell, 1983).

Recently a new descriptive phrase has been substituted for non-use values. Following the *Ohio* decision of 1989, the term "passive use values" was increasingly substituted for “non-use values”. The latter term sounded contradictory to people not familiar with the practice of non-market valuation (Arrow, *et al.*, 1993; Amack, 1994; Randall, 1996).

Within the non-market valuation research literature there is some inconsistency regarding the use of the term passive use value. Some analysts continue to include all components of value, including option and quasi-option value, which are not based upon the consumptive or non-consumptive use of a resource (Reaves, 1996). Some analysts define option value and quasi-option value as components of use value based upon their derivation from the use, albeit deferred use, of a commodity (Randall and Kriesel, 1990). The choice of correct measure in evaluating total non-use value remains conceptually ambiguous. This research will define passive use values to include only existence and bequest values.

Some value may be derived from the vicarious use of an amenity, such as the enjoyment of photographs of or documentaries about a resource. While based upon the indirect use of a resource, vicarious use values may be difficult to quantify or differentiate from non-use value and so may be included by some analysts as passive use values (Randall, 1991).

Previous Research on Biodiversity Valuation

Previous literature on the value of biodiversity includes the development of conceptual and empirical models for various components of value. The relevant components addressed in these models include consumptive use value, nonconsumptive use value, option value, and passive use values. Much of the value of biodiversity is associated with its contributions to ecosystem resiliency. Because biodiversity supports or maintains some other ecosystem functions, many researchers have focused on the indirect use value as a factor in the provision of other resources (Holling, *et al.*, 1995; Perrings, *et al.*, 1995b). Turner, *et al.*, (1995) estimate the value of biodiversity by calculating the replacement cost of water purification services and the loss of life support systems via estimated lost capacity of wetland plants to capture solar energy in Gotland Island, Sweden. They also estimate the willingness to pay to preserve ecological services in an English wetland using the contingent valuation method.

Biodiversity depletion has also been included as a constraint in natural resource use model. Swanson (1995a) and Rowthorn and Brown (1995) model the optional conversion rate for natural habitat considering biodiversity loss. Recognizing the importance of biodiversity in the larval stage of pelagic fish, Brown and Roughgarden (1995) configure an optimal fishery model factoring in the conservation of biological diversity. Other resource allocation models considering biodiversity depletion have been proposed for timber harvesting (Barbier and Rauscher, 1995) and grazing (Perrings and Walker, 1995).

A number of sources regarding biodiversity depletion have expressed a concern for the loss of information from potentially beneficial species currently undiscovered or unrecognized by science or technology. The species driven into extinction may be a lost source of value to medicine, research, or industry (Waller, 1996). These arguments for biodiversity preservation focus on option values or quasi-option value. Sedjo and Simpson (1995) and Simpson, Sedjo, and Reid (1996) estimate a model of option value for pharmaceutical products.

Other models for biodiversity have modeled biodiversity based on the phylogenetic distinctiveness of species. The value of certain species may be related to their uniqueness in taxonomic terms. Species from relatively less abundant phylogenetic categories, i.e., phyla, classes, orders, and families, may be more valuable than those from common categories. Phylogenetic distinctiveness may be an important consideration in estimating option value, quasi-option value, and existence value (Weitzman, 1995; Solow, Polasky, and Broadus, 1993).

Existence Value

Existence value is that value not associated with the use of a particular asset. Krutilla and Fisher (1975) suggest that existence value is assigned by individuals to commodities they will never use *in situ*. A more precise definition describes existence value as being separate from any use (McConnell, 1983).

Following McConnell (1983), let x be a vector of n market goods sold at fixed market prices p and let R be the resource the value of which may be valued. The resource R may be a measure of either quantity or quality, over which typically the individual consumer has no control (Freeman, 1993). Assume individuals possess a quasi-concave utility function, u(x, R), which is increasing in both market goods x and "existence" good, R. The objective of the individual consumer is to maximize utility subject to a budget constraint (Freeman, 1993):

$$\max_x u(x, R) \quad \text{s.t. } px \leq Y \tag{2.1}$$

where $\partial u/\partial x > 0 \qquad \partial u/\partial R > 0.$

Existence demand exists when the utility function, $u(x, R)$ is weakly separable in the bundle of market goods, x, and existence good, R (McConnell, 1983). A utility function is weakly separable if:

$$\frac{\partial[(\partial u(x, R)/\partial x_j)/(\partial u(x, R)/\partial x_i)]}{\partial R} = 0 \qquad (2.2)$$

That is, existence demand for commodity R exists if the marginal rate of substitution between any two market goods, x_j and x_i , is independent of the provision of R (McConnell, 1983; Chambers, 1988). The utility derived from knowledge of the existence of the commodity is distinct from the impact on utility that commodity may have, directly or indirectly, by altering preferences for other commodities. Existence demand for biodiversity, for example, is said to exist if knowledge of the condition of biological diversity does not have an effect on the real estate market or recreation market by altering the preferences for housing or recreation. This precludes the use of hedonic or travel cost methods as an appropriate measure of existence value. Weak separability can also be illustrated by rewriting the utility function as:

$$U = U(u_1(x) + u_2(x)), \qquad (2.2a)$$

(Henderson and Quandt, 1980). If the overall utility function $u(x, R)$ is weakly separable, the optimal choice of the good R can be found by using a subutility function for that particular good (Varian, 1992).

From the utility function $u(x, R)$, the following cost function can be defined:

$$e(p, R, u) = \min \{p'x |\, u(x, R) = u\}. \qquad (2.3)$$

The Hicksian compensating surplus can be found for a change in the provision of R by calculating the different expenditures needed to attain the initial level of utility, $u_0 = u(x, R_0)$:

$$CV = e(p, R_1, u_0) - e(p, R_0, u_0). \quad (2.4)$$

Similarly, the Hicksian equivalent surplus is calculated using as a reference the subsequent level of utility, $u_1 = u(x, R_1)$:

$$EV = e(p, R_1, u_1) - e(p, R_0, u_1) \quad (2.4a)$$

(Madriaga and McConnell, 1987; McConnell, 1983; Freeman, 1993).

Differentiating Use Value and Existence Value

The total value of a commodity is a function of use value and non-use values. How the total value of a resource may be calculated depends upon the nature of the interaction between use values and non-use values. The separate components of value must be clearly distinguished in the estimation of the welfare benefits of any commodity which may possess both use and non-use values (Randall, 1991; Randall, Hoehn, and Swanson, 1990).

A change in a resource for which individuals hold existence value may also affect a change in the use value which that commodity may also possess. It may also affect the use value of a market commodity to which the existence valued commodity may somehow be connected. In order to obtain a meaningful estimate of existence value, the researcher must make certain assumptions about the characteristics of the commodity in question and its relationship to other goods (Freeman, 1993).

One of the assumptions made in distinguishing between use and non-use values concerns weak complementarity. The concept of weak complementarity is usually illustrated by referring to some market good x_1 which has as an argument in its demand function (or production function), the provision of R. By assumption, R is included as an argument only for good x_1 and not for any other market good, $x_2, \ldots, x_n$. An increase in the level of R results in an increase in the demand for good x_1 (but no other market good, x_i.) For instance, the market commodity, x_1, may be deer hunting which may increase with an increase in biodiversity (Freeman, 1993). If the demand for x_1 were zero, an increase in the level of R may not affect utility:

$$\partial U(x_1 = 0, x_2, \ldots, x_n, R)/\partial R = 0 \tag{2.5}$$

(Madriaga and McConnell, 1987). The consumption of market commodity x_1 will be zero at prices at or above the "choke price", p_1^*. For example, an individual may consume no deer hunting activities in a particular area if the price of hunting there were to be set above the choke price, p_1^*. The assumption of weak complementarity implies that the existence value for biodiversity is not changed by the change in deer hunting. The concept of a choke price may be used in expenditure functions in estimating Hicksian measures of welfare (Randall, 1991).

Another condition of weak complementarity states that when commodity R falls below a certain level, none of the market good x_1 will be produced. If the minimum level of R necessary for production of x_1 is R_{min}, and $R_0 < R_{min}$, then

$$u(x, R_0) = U(x_1 = 0, x_2, \ldots, x_n, R). \tag{2.6}$$

This introduces a form of symmetry because at low levels of R (i.e., $R_0 < R_{min}$),

$$\partial u(x, R_0)/\partial x_1 = 0. \tag{2.6a}$$

This form of symmetry carries over to the expenditure function that can be used in estimating the Hicksian welfare measures (Madriaga and McConnell, 1987).

If the assumption of weak complementarity holds true, the total change in benefits resulting from a change in the provision of R may be measured by the Hicksian compensated demand for market good, x_1. Resources measured by use of the assumption of weak complementarity are use values because they are tied to the consumption of a market commodity (Freeman, 1993).

In order to estimate existence value, the assumption of weak complementarity must be violated. Existence values may be estimated by demonstrating a change in expenditures for R when consumption of x_1 is zero, that is, price is above choke price, p_1^*, and the level of R rises from below R_{min} ($R_0 < R_{min}$) to R_1, (a baseline level of R):

$$CS = e(p_1^*, R_0, u_0) - e(p_1^*, R_1, u_0) \tag{2.7}$$

(Randall, 1991).

Bequest Values

Bequest values are based upon the utility a person derives from the utility level of another person, typically perceived as heirs or succeeding generations. If an individual gains benefit from the utility of another, u_H, his utility function may be rewritten:

$$u = u(x, u_H) \tag{2.8}$$

If the well-being of the heirs depends upon the availability of R, $u_H = u_H(R)$ then the individual's utility function becomes:

$$u = u(x, u_H(R)) = u(x, R) \tag{2.9}$$

implying that there is no way to distinguish bequest values from existence values (McConnell, 1983). McConnell and Madriaga (1987) suggest that motives for existence values do matter. Because many of the motives behind existence values remain unobservable, they recommend research into the cause of motivation.

Previous Empirical Research

Empirical efforts to estimate the value of environmental amenities have frequently focused on one component measure of value. Previously, non-market valuation techniques have been employed to measure separately use value (Bishop and Heberlein, 1979), option value (Desvouges, Smith, and Fisher, 1987), and existence value (Samples, Dixon, and Gowan, 1986; Boyle and Bishop, 1987). Although some empirical applications have sought to estimate more than one element of value (Brookshire, Eubanks, and Randall, 1983; Barrick and Beazley, 1990), many researchers have preferred to avoid some of the theoretical problems and methodological difficulties (Randall, 1991a) associated with the simultaneous estimation of multiple component values.

The economic literature for the measurement of the benefits of endangered species contains many estimates of existence values. A number of these studies elicit the existence value of a particular threatened or endangered species in a given location. Bowker and Stoll (1988) measured the value of preservation of the whooping crane (*Grus americanus*). Samples, Dixon, and Gowan, 1986) estimated the valuation of the humpback whale (*Megaptera novaeangliae*). Hagen, Vincent, and Welle (1992) estimated willingness to pay to preserve the northern spotted owl (*Strix occidentalis caurina*) in the Pacific

Northwest. Reaves, *et al.* (forthcoming) measure the economic benefits of preserving the red-cockaded woodpecker (*Picoides borealis*). Other studies have measured the existence values of bighorn sheep (*Ovis canadensis*) and the northern Rocky mountain gray wolf (*Canis lupus lupus*) (Loomis and White, 1995).

Some non-market valuation studies have elicited the existence value of a variety of species in a single survey instrument. Stevens, *et al.* (1991) used one survey to estimate the existence value of three species, the bald eagle (*Haliaeethus albicella*), wild turkey (*Meleagris gallopavo*), and coyote (*Canis latrans*) in New England and a separate survey for the Atlantic salmon (*Salmo salar*). Boyle and Bishop (1987) elicited the willingness to pay to preserve two seemingly unrelated species, the bald eagle and the striped shiner (*Notropis chrysocephalus*), in one Wisconsin survey instrument. Other studies have measured the existence value of related species, e.g., sea mammals (Hagemann (1985) and Samples and Hollyer, 1991) and birds (Loomis, 1989; Loomis, *et al.*, 1990; and Rowe, Shaw, and Schultze (1992) *in* Loomis and White ,1995).

Walsh, *et al.*, ((1985) *in* Loomis and White, 1995) estimated the value of twenty-six threatened and endangered species using 198 thirty minute personal interviews of households in Colorado. They offered three levels of protection: removal from the threatened or endangered list, prevention of habitat and population decline, and the termination of protection which may result in extinction. The research included estimates of recreation use, option, existence, and bequest value.

Bishop and Welsh (1992) discuss the difficulty of estimating the existence values of individual species by making reference to Boyle and Bishop (1987). They urge caution in the interpretation of contingent valuation estimates of existence values for environmental goods for which there are close substitutes. Obscure resources, for example the striped shiner and the Higgins-eye pearly mussel, may be highly substitutable. This may affect the magnitude of the existence value of the individual species and the "adding up" of the separate estimates.

The problem of estimating the value of a multi-attribute commodity was approached by Bergstrom and Stoll (1987) with the "piece-wise" valuation procedure. They estimated the willingness to pay for a program with four separate components. However they found that respondents found it difficult to give their willingness to pay for separate components. The respondent's valuation of components were sensitive to both survey instrument construction and the manner in which the component values were elicited. Analysis of government policy decisions (Metrick and Weitzman, 1996) and meta-analysis studies (Loomis and White, 1996) indicate that the magnitude of value may vary significantly according to species type. Existence values for "charismatic mega-fauna" may likely exceed less-attractive species. Similarly, a survey instrument designed to elicit the passive use value of biodiversity may be affected by the description of the species within the ecosystem.

Whitehead and Blomquist (1991) estimate the existence value of a bottomland hardwoods forest in western Kentucky. Because the survey instrument does not elicit the willingness to pay for the species inhabiting the swamp, it provides an estimate of the value of all the ecosystem functions it provides, including, but not limited to, biodiversity. Dillman, Beran, and Hook (1993) estimate the willingness to pay for the preservation of three types of wetlands in South Carolina but similarly is not limited to valuation of biodiversity functions.

Modelling the Value of Biodiversity

The valuation of biodiversity depends upon the definition of biodiversity accepted by the analyst. The three standard types of biodiversity, genetic diversity, species diversity, and ecosystem diversity, are all diminished by the extinction of species but are affected by a decline in biodiversity differently according to the focus of the definition. Solow, Polasky, and Broadus, (1993) provide a framework for measuring biodiversity based upon the probability of extinction for a species and the genetic relationship to similar species (e.g., the whooping crane, *Grus americanus*, and the sandhill crane, *Grus canadensis*.) Because of the focus on genetic characteristics with likely practical applications, this model seems especially appropriate for measuring use values.

Brown and Goldstein (1984) provide a model for valuing endangered species which may be applied to biodiversity. In this model, the value of species preservation is derived from the genetic information each species carries. Closely resembling a model for the measurement of genetic biodiversity, this model seems to estimate a use value for biological diversity.

Estimating the value of biodiversity differs from these previous studies. The object of biodiversity valuation is not to estimate the values of a number of species measured separately or collectively in small grouping. The valuation of biological diversity will measure the welfare benefits of maintaining a system of different species within an ecosystem.

The total value of biodiversity can not be elicited as some aggregate of its constituent species. For one, there may be some disagreement about which species occur within an ecosystem. Some species may appear or disappear from an ecosystem without being documented by natural scientists, making an accurate listing difficult to attain. Another consideration concerns the ability of respondents to comprehend an extensive list of plant and animal species, some with which they may be unfamiliar.

Theoretical concerns may also preclude the estimation of the passive use value of biodiversity as an aggregative function of its constituent species. Substitutability or complementarity among particular species may make it impossible to add up the value of biodiversity as a sum of its parts (Mitchell and Carson, 1989; Randall, Hoehn, and Brookshire, 1983; Randall, 1991a; Bishop and Welsh, 1992). In a case study of Mono Lake, California, Loomis (1989) estimates the value of a multi-component program as less than the sum of the estimated value of its component programs. Similarly, the value of biodiversity would be expected to be less than the sum value of all the species within the ecosystem.

According to Kiker (1996), the valuation of biodiversity may also depend upon the use of ecological "endpoints", individual components which may be used as a measure or indicator of the composite commodity. Possible "ecological endpoints" may consist of "keystone" species, individual species whose status indicates the health of the ecosystem (Hagen, Vincent, and Welle, 1992; Wilson, 1992; Metrick and Weitzman, 1996), or area preserved for habitat (Wilson, 1992; Krautkraemer, 1995; Rowthorn and Brown, 1995).

Two models (Krautkraemer, 1995; Rowthorn and Brown, 1995) provide a conceptual framework for the valuation of passive use value of biodiversity using a relationship between the number of species within an ecosystem and the size of the area provided as natural habitat. Building on MacArthur and Wilson's theory of island biology, Wilson (1992) suggests a log-linear relationship between the number of species, S, and area of habitat, A:

$$S = CA^z, \tag{2.10}$$

where C is a positive parameter and z ranges from 0.10 to 0.35. Krautkraemer (1995) uses this relationship to illustrate the relationship between land development, population growth, and economic output and, in turn, preserved habitat.

Rowthorn and Brown (1995) develop a utility function incorporating consumer goods and biodiversity maintenance through habitat preservation. The model uses the relationship between species diversity S and habitat area A in forming a utility function which includes biodiversity as an argument. This model treats all species as homogeneous units within a composite commodity. An equation adapted from equation (2.1) yields a utility function which is a positive function of a vector of consumer commodities x and an environmental amenity, biodiversity S :

$$\text{Max } u = u(x, S = h(A)) \tag{2.11}$$

subject to $px \le Y$, where $\partial u/\partial x > 0$ and $\partial u/\partial S = (\partial u/\partial h)(\partial h/\partial A) > 0$. This model assumes that the condition of weak separability between market commodity and biodiversity existence good holds.

From the utility function u(x, S), the following cost function can be defined:

$$e(p, S, u) = \min \{p'x \mid u(x, S) = u\}. \qquad (2.12)$$

The Hicksian welfare surplus measure can be found for a change in the provision of biodiversity S ($S_i \neq S_j$) by calculating the different expenditures needed to attain the desired level of utility, $u_i = u(x, S_i)$:

$$HV = e(p, S_j, u_i) - e(p, S_i, u_i). \qquad (2.13)$$

If u_i is the initial level of utility, equation (2.13) gives a measure of Hicksian compensated variation. If it is the level of utility subsequent to a change in the level of biodiversity, equation (2.13) gives a Hicksian equivalent measure.

Willingness to pay and willingness to accept compensation are measures of Hicksian welfare following a change in the level of biodiversity. Because the level of species diversity is a function of the area of habitat, the willingness to pay for biodiversity may as a result be related to the willingness to pay for ecosystem habitat preservation.

Although the relationship of habitat area to species diversity remains, it may be inappropriate to apply the theory of island biogeography central to Rowthorn and Brown's model to local environmental management decisions. While the theory of island biogeography explains biodiversity variation on a global scale, it is often too general to describe accurately the species variation for specific habitat circumstances (Budiansky, 1995). Additional parameters besides habitat area contribute to the number of species present including geographical location of the habitat (Reid, 1992), forest fragmentation (Simberloff, 1992), population size, the adaptability of species to secondary forest growth

(Heywood and Stuart, 1992), and the degree and nature human disturbance (Brown and Brown, 1992).

The conceptual model in this research adapts Rowthorn and Brown's model to address local biodiversity conservation. The use of area of preserved habitat as a measure of species diversity found in the theory of island biogeography is supplanted by factors relevant to local biodiversity, for example, the maintenance of sustainable populations of particular keystone or umbrella species. Biodiversity valuation can be approximated by estimating the value of maintaining the conditions which protect the variety of plant and animal species in the local ecosystem. The required protected area and other environmental factors should be determined by local environmental policy framers, planners, and managers.

Conclusion

This chapter investigates the economic theory underlying the valuation of biodiversity and presents a conceptual model to be used in this effort. As Rowthorn and Brown (1995) modeled the value of biodiversity as a function of the area which supports or sustains the diversity of species, the conceptual model in this research estimates the passive use value of biodiversity by estimating the value of the habitat needed to maintain the biologically diverse resources within the Tensas River basin.

The contingent valuation method is the appropriate non-market valuation technique for the estimation of the value of biodiversity. Previous research on the valuation of endangered species has focused on a single species in a particular habitat. This research extends previous research by conceptualizing the value of biodiversity, defined here as the variety of species which exist within an ecosystem, by adapting a model based on Rowthorn and Brown. Recognizing the weaknesses of applying the theory of island biogeography to the management of local species biodiversity, this research applies the alternative standard of habitat conservation for umbrella or keystone species.

The following chapter addresses the modifications of previous non-market valuation procedures needed to estimate the value of biodiversity. It presents data collection procedures, including the development of the survey instrument. Empirical estimation of the passive use values of biodiversity follows.

Chapter III

Data Collection and Descriptive Statistics

Introduction

Previous research in the valuation of biological and environmental assets have elicited the value of a well-defined amenity, such as a single species or species habitat. Efforts to estimate the value of biodiversity are complicated by the comparatively unknown and unrecognized ecological benefits of this natural resource. The ability of an individual to assess the value of a commodity depends in part upon his or her capacity to conceptualize the good in question. The complexity of biodiversity may complicate or impair an individual's capacity to assign a definable value. This research will address the proper framing of the contingent valuation method to test the ability of individuals to provide quantifiable benefit measures for this natural resource.

Empirical estimation of the total economic value of many natural amenities has frequently concentrated on component values, including use value and non-use or passive use value. Passive use values have been defined in this research to include existence value and bequest value. Because of the nonexclusive nature of the passive use of biodiversity, a proper price mechanism will not arise for this component of value (Randall, 1993).

The contingent valuation method depends upon the use of surveys which directly elicit willingness to pay or willingness to accept compensation for some change in the provision of an environmental amenity. The empirical requirements and theoretical needs of the direct valuation technique demand a survey instrument which elicits the value of a particular unit of a specific, well-defined good. The respondent must clearly understand the question in order to provide the analyst with a meaningful response.

Framing Issues

The framing of the contingent valuation instrument has important theoretical and empirical implications for the valuation of biodiversity. The indefinite content of the biodiversity "bundle", that is, the myriad species which constitute the biological resource, makes the definition of the commodity an important research issue. This research will address the issue of the proper framing of the contingent valuation method for this special case.

Three common measurements have been identified for the various aspects or components of biodiversity: genetic diversity, species diversity, and ecosystem diversity (Pearce and Moran, 1994). As discussed in Chapter II, this research will address species biodiversity, the definition which seems most applicable to the policy instrument affecting the study region. The policy focus on the role of biodiversity in the stability of ecosystems as distinguished from a policy focus on its value as a store of genetic stock has important implications for the cost of biodiversity loss (Perrings, 1995).

Neither the scientific community nor the general public is able to specify the precise role of particular units of biodiversity, the particular species of plants and animals within an ecosystem, in contributing to human and ecological welfare. Using species as a unit of change may conceptually reflect the pertinent change in the biological diversity resource but may be empirically difficult due to the large number of species present in an ecosystem. As an additional complication, in many ecosystems, a number of the composite species may be uncataloged or unrecognized. There are also theoretical reasons which preclude the valuation of the whole as an aggregate of the valuation of individual component species. For example, framing the contingent valuation instrument as a function of the change in the number of species or species populations in an ecosystems may have the advantage of providing a welfare estimate in terms of the direct unit of change. The disadvantage is that this approach may not provide the clarity needed in a contingent valuation method.

An alternative approach focuses on the preservation of habitat for the maintenance of biodiversity. Two models (Krautkraemer, 1995; Rowthorn and Brown, 1995) provide a conceptual framework for biodiversity valuation using a relationship between the number of species within an ecosystem and the size of the area provided as natural habitat. Building on MacArthur and Wilson's (1967) theory of island biology, Wilson (1992) suggest a log-linear relationship between the number of species, S, and area of habitat, A:

$$S = cA^z, \tag{3.1}$$

where c is a positive parameter and z ranges from 0.10 to 0.35. Krautkraemer (1995) uses this relationship to illustrate the relationship between land development, population growth, and economic output (GDP) and, in turn, preserved habitat. Rowthorn and Brown (1995) develop a utility function incorporating consumer goods and biodiversity through habitat preservation. This research incorporates concepts from both of these models in the compilation of the contingent valuation survey.

The Empirical Model

This section presents a valuation framework that identifies the value of biodiversity as a function of various economic parameters and socioeconomic characteristics. This model is used in the construction and development of the survey instrument used to collect the data for empirical analysis of the value of biodiversity.

The passive use value of biodiversity can be derived from the individual utility maximization model developed in chapter two (equation 2.13). This model hypothesizes that the passive use value of biodiversity is influenced by the provision or state of biodiversity, S, the individual's preferences for outdoor recreation, O, the individual's preference for environmental quality, E, income, Y, and a number of socioeconomic characteristics, C. The value of biodiversity is expressed in the following equation:

$$V = f(S, O, E, Y, C). \tag{3.2}$$

The state of biodiversity may be measured either directly as a function of the number of species preserved or, following Wilson and MacArthur (equation 3.1), indirectly as a function of habitat preserved for species preservation as expressed below:

$$V = f(S(A), O, E, Y, C). \tag{3.2a}$$

Because previous research has shown a positive relationship between utility and individual endangered species, passive use value of biodiversity is assumed to be positively related to the status of the amenity within an ecosystem.

Individuals who participate in outdoor recreation are distinguished from those who do not by their personal contact with particular natural resources. Individuals with a greater degree of personal knowledge of a resource may assign a larger value to that commodity

(Loomis, 1989; Loomis, *et al.*, 1990). Outdoor recreationists' personal experience with biodiversity may result in a greater appreciation for the variety of species within an ecosystem.

Participants in outdoor recreation can be further distinguished by the nature of the activity in which they take part. Those who participate in nonconsumptive forms of recreation, i.e., hiking, canoeing, birding, and photography, may hold preferences different than those who take part in consumptive recreational activities, i.e., hunting, fishing, and trapping (Dufus and Dearden, 1990; Mangun, O'Leary, and Mangun, 1992). Nonconsumptive outdoor recreationists, due to their personal experience, may value natural habitats which include a wider variety of plant and animal species. The passive use value for biodiversity may be positively associated with an individual's participation in nonconsumptive outdoor recreation.

Outdoor recreationists may possess a greater degree of knowledge of natural environments than those who do not recreate outdoors. This familiarity with natural environments may be associated with a greater sensitivity of utility to the state of biodiversity. Individuals who take part in consumptive recreation may possess a different set of preferences for environmental amenities. Such individuals may possess a more utilitarian valuation for natural resources which is more biased towards use values than passive use values. In addition, policy instruments designed to maintain biodiversity may reduce the quality of consumptive recreational activity. For example, a policy intended to improve the state of biological diversity by increasing the amount of vegetative cover may be perceived to decrease the quality of deer hunting by reducing the area of forest "edge" preferred by deer. As a result, no *a priori* assumptions regarding the relationship between consumptive recreational activity and the value of biodiversity is made.

Because individuals who are personally familiar with a resource are more likely to form a higher value for the good (Mitchell and Carson, 1989; Stevens, *et al.*, 1991; Hagen, Vincent, and Welle, 1992), individuals who have participated in recreational activities within the area being valued may place a higher value on its preservation. A positive relationship between a person who has made a visit to the area and the passive use value of biodiversity is hypothesized.

Individuals who hold a higher degree of preferences for environmental amenities are hypothesized to hold a greater value for biodiversity. Preferences for environmental amenities are not directly observable but may be estimated indirectly through membership in environmental organizations and previous donations to environmental causes (Bowker and Stoll, 1983; Loomis, *et al.*, 1990; Stevens, *et al.*, 1991). Attitudes towards the environment may be solicited by requesting answers regarding the importance of environmental preservation and knowledge of environmental conditions (Stevens, *et al.*, 1991; Loomis, *et al.*, 1990). Another instrument which can be used to gauge environmental preferences is the New Ecological Paradigm (NEP), a summative scale designed to measure an individual's attitude towards the environment (Dunlap, *et al.*, 1992). Persons who hold a higher ethical value for the environment, as indicated by the score on the New Ecological Paradigm, are hypothesized to possess a greater value for biodiversity.

Previous research on endangered species has included as variables in the utility function a number of socioeconomic variables, including income, age, gender, education, and place of residence. Biodiversity, like some endangered species (Reaves *et al.*, forthcoming) and other environmental amenities (Panayotou, 1993), is assumed to be a normal economic good. A positive relationship is assumed between income and the passive use value of biodiversity.

Because younger individuals may possess a higher preference for environmental amenities, age may be negatively related to passive use values for biodiversity. However, because passive use value includes bequest values (Randall, 1996), older individuals may be more aware of their contribution to the utility of future generations. This theoretically would have a positive influence on the value of biodiversity. Based on previous research, no *a priori* assumption regarding the relationship between age and passive use value of biodiversity is asserted. Similarly, while gender is hypothesized to be a factor in preferences for biological diversity, the sign of the relationship between gender and the value biodiversity is not predicted *a priori*.

Individuals with higher amounts of education may have higher preferences for environmental amenities. Education is assumed to influence positively the individual's value of preserving biodiversity. Other demographic characteristics, such as place of residence, may affect preferences for biodiversity. Individuals who live in cities or towns of different sizes may hold different values for biodiversity. Individuals who live in more rural areas may be more familiar with natural resources because of their closer relative proximity to certain environmental amenities, such as wildlife habitat. This familiarity may prompt individuals in more rural areas to hold a greater value for environmental amenities.

Conversely, residents in more rural areas may hold a higher preference for use values which may result in diminished passive use values. Further, residents in more rural areas may have lower incomes than residents of larger cities and thus lower preferences for biodiversity. As a result plausible competing hypotheses, no *a priori* relationship between the population of the city of residence and passive use value of biodiversity is assumed.

The state of residence may influence an individual's preferences for biodiversity. Even though the borders of an ecosystem may extend across political boundaries, individuals who reside in nations or states other than that enclosing the area being valued may assign less value to its preservation, even though the possession of passive use values is not necessarily limited to a redistricted geographical location.

With these general hypotheses, a more detailed model for the valuation of the passive use of biodiversity is proposed. The predicted value of the factors' influence upon the value of the environmental amenity is included in parentheses:

$$V = f\,(S(A)\ (+),\ \text{Nonconsumptive Recreation}\ (+),\ \text{Consumptive Recreation}\ (+/-),\ \text{Environmental Attitude}\ (+),\ \text{Socioeconomic Variables}\ (+/-)). \qquad (3.3)$$

Willingness to Pay versus Willingness to Accept Compensation

The traditional measure of welfare is consumer surplus which is equivalent to the area beneath the Marshallian (ordinary) demand curve and above the price range. Because Marshallian demand allows variation of utility level, there have been problems with using consumer surplus as a measure of benefits resulting from a change in price or quantity (Silverberg, 1978 *in* Mitchell and Carson, 1989).

Hicks (1939 *in* Braden, Kostad, and Miltz, 1991; 1941, 1943, 1956 *in* Mitchell and Carson, 1989) suggested an alternative welfare measure holding constant utility as price or quantity change: compensating variation (or surplus) and equivalent variation (or surplus). Compensating variation is defined as the quantity of income that compensates a consumer for a price change by returning him or her to the original level of utility:

$$CV(p_0, p_1) = e(p_1, u_0) - e(p_0, u_0). \qquad (3.4)$$

Equivalent variation is defined as the income change that would be required in place of a price change in order to reach the same level of utility that would have been attained with the price change:

$$EV(p_0, p_1) = e(p_1, u_1) - e(p_0, u_1). \qquad (3.5)$$

The differences between compensated variation and equivalent variation are illustrated using the Hicksian demand curves in Figure 3.1. Equations 3.4 and 3.5 can be illustrated using Hicksian demand curves, $h(p, u_1)$ and $h(p, u_0)$, because Hicksian demand curves are equivalent to the derivative of the expenditure function with respect to prices. The compensated variation is equivalent to the area to the left of the curve $h(p, u_0)$ and between prices p_1 and p_0, area (ACDF). The equivalent variation is shown by the area to the left of the curve $h(p, u_1)$ and between prices p_1 and p_0, area (ABEF). Consumer surplus is described as the area to the left of the ordinary or Marshallian demand curve between prices p_1 and p_0, area (ACEF) (Kolstad and Braden, 1991).

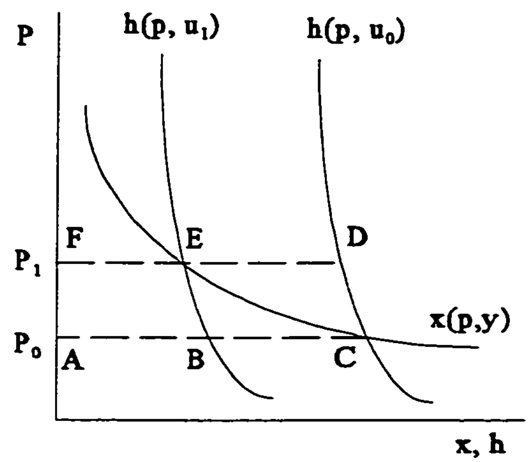

Figure 3.1 Ordinary and Hicksian Demand
Source: Kolstad and Braden, 1991, p. 31.

For many environmental goods, welfare measures are concerned with a change in the quantity of a good rather than a change in price. Biodiversity and other environmental goods can be treated as non-priced commodities. In such cases, compensating and equivalent variation may be rewritten as a function of quantity:

$$CV(p_0, p_1) = e(p, q_1, u_0) - e(p, q_0, u_0). \tag{3.4a}$$

$$EV(p_0, p_1) = e(p, q_1, u_1) - e(p, q_0, u_1). \tag{3.5a}$$

where p is a vector of fixed commodity prices and q_i represents alternative quantities of a good. Figure 3.2 illustrates compensated and equivalent variation following a quantity change, holding composite commodity price fixed at p*. Utility curves u_0 and u_1 are shown for preferences between q and x, a composite market commodity. The budget curve is shown as y = p*x, a horizontal line.

The compensating variation following an increase in the quantity of the environmental good is the reduction in income necessary to reduce consumption of the composite good by CV/p*, an amount sufficient to return to the initial utility curve, u_0. The equivalent variation is EV/p*, the amount of the composite commodity needed instead of the increase in the environmental commodity to place the consumer on the same utility curve u_1 that would have been attained had the environmental commodity increased (Kolstad and Braden, 1991). Randall and Stoll (1980) recommend Hicksian variation measures when the quantities of the good may be finely varied. If the consumer is restricted to consume the commodity in fixed or lumpy quantities, compensated or equivalent surplus measures should be used. Table 3.1 summarizes the appropriate Hicksian measure corresponding to positive or negative changes in price or quantity.

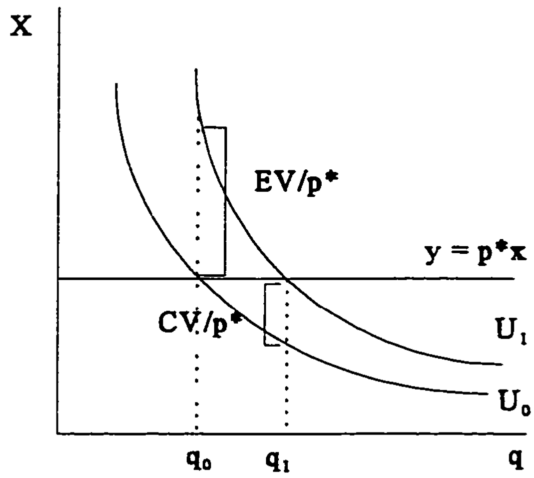

Figure 3.2 Surplus with Quantity Change
Source: Kolstad and Braden, 1991, p. 31.

Table 3.1 Hicksian Measures for Contingent Valuation Surveys

Change	Willingness to Pay	Willingness to Accept
Quantity increase	Compensating surplus	Equivalent surplus
Price decrease	Compensating surplus; Compensating variation	Equivalent surplus; Equivalent variation
Quantity decrease	Equivalent surplus	Compensating surplus
Price increase	Equivalent variation	Compensating variation

Source: Mitchell and Carson, 1989

The Empirical Difference Between WTP and WTA

Willig (1976) hypothesized that the difference between WTA and WTP should be relatively small for changes in price in a "well-behaved" utility function. Randall and Stoll (1980) revised Willig's findings for changes in quantity. The differences for WTA and WTP should be relatively small for any commodity the expenditures for which are a small portion of total income.

In applied research, the difference between WTA and WTP has been larger than the Randall and Stoll hypothesis may imply. Hammack and Brown (1974) found that WTA was more than four times as large as WTP in a study of waterfowl preservation benefits. Other studies seemed to contradict Willig's (1976) claim that the difference between WTP and WTA was a "methodological artifact." Laboratory experiments by Bishop and Heberlein (1979), Bishop, Heberlein, and Kealy (1983), and Gregory (1986) indicate that the WTP<WTA difference could not be attributed to the hypothetical nature of method of the contingent valuation question.

The difference in WTA and WTP may be attributed to a rejection of the property rights scheme described in the WTA format (Bishop and Heberlein, 1979; Mitchell and Carson, 1989), the risk aversion of the respondents (Hoehn and Randall, 1987), or other modification and reinterpretations of economic theory. Hanemann (1982, 1983b, 1984b, 1984c *in* Mitchell and Carson, 1989) believes that the difference between WTA and WTP may be inflated by the small elasticity of substitution associated with some environmental goods.

The Selection of WTP Format

Based upon previous theoretical and empirical research, analysts have recommended that contingent valuation surveys use WTP questions. Researchers typically prefer WTP as this format provides more reliable and consistent measures of benefits. Because the nature of WTP is more familiar to respondents than WTA, WTP questions are less vulnerable to strategic bias (Swanson and Peterson, 1988; Mitchell and Carson, 1989).

Analysts who have investigated the contingent valuation method recommend the conservative measures of benefit (Arrow, *et al.*, 1993). Because the empirical estimates of WTP are generally much less than estimates provided by WTA questions (Bishop, Heberlein, and Kealy, 1983), they identify WTP as the appropriate format in most cases (Cummins, Brookshire, and Schulze, 1986; Mitchell and Carson, 1989).

Cummings, Brookshire, and Schulze (1986) suggest among the four reference operation conditions (ROC) that "WTP, not WTA, measures [be] elicited" (Cummings, *et al.*, 1986, p. 107). Arrow, *et al.*, (1992) reiterate this suggestion in their recommendations regarding the contingent valuation method. Mitchell and Carson (1989) offer a less firm recommendation in favor of the WTP format, preferring WTP measures except in cases involving privately-held publicly goods at currently accessible levels. Because the passive use of biodiversity is considered a collectively-held public good (Randall, 1991), the object of this valuation study is not characterized by the property rights scheme for which Mitchell and Carson recommend the WTA format.

Previous research has found that WTA estimates, even when conceptually appropriate, are frequently of suspected reliability. The WTA format is more vulnerable to upward bias as respondents may provide unrealistically high responses. Compared to the alternate format, the WTP format increases the reliability of the estimate by reducing ambiguity and incentives to provide inflated responses. The WTP is preferred as the conservative format which provides smaller and more reliable estimates than the WTA format. This research adheres to the recommendations found in the National Oceanic and Atmospheric Administration (NOAA) Blue Ribbon Panel (Arrow, *et al.*, 1993) and reviews of previous literature and employs the WTP format.

Bid Elicitation Method

The elicitation method is important in estimating the maximum the respondent is willing to pay for the amenity before he or she would prefer to go without it. Previous research has identified the most frequently used elicitation methods in contingent valuation as the open-ended format, the bidding game, payment card, dichotomous choice, and multiple bounded dichotomous choice elicitation formats.

The open ended elicitation format asks the respondent to provide the maximum amount he or she is willing to pay to avoid going without the amenity (Devouges, Smith, and Fisher, 1987; Rieling, *et al.*, 1996). While the responses obtained by this method may seem to provide a clear measure of each individual's maximum willingness to pay, it is difficult for respondents to choose a value without assistance just as it may be difficult for individuals to assign a maximum willingness to pay for an unpriced consumer good. The difficulties attending this elicitation method often result in large non-response rates or a large number of protest zero responses, a WTP of zero when the good possesses some value for the respondent (Mitchell and Carson, 1989; Welsh and Poe, 1996). Further, the open ended format may appear unrealistic since respondents are not frequently asked to place a dollar value on public goods. This unrealistic format may also result in a number of large protest bids, expressed WTP in excess of the value of the good in order "to make a point" (Arrow, *et al.*, 1993, p. 4606). This sort of exaggerated overstatement or understatement of willingness to pay is an example of strategic bias, the statement of a WTP value different from the true WTP in an effort to influence the level of the good or the respondent's level of payment for the good (Mitchell and Carson, 1989; Kealy and Turner, 1993).

The bidding game, another elicitation method, employs an auction-like process in eliciting the respondent's maximum willingness to pay for the amenity (Desvouges, Smith, and Fisher, 1987; Mitchell and Carson, 1989). This method is familiar to participants and can provide a full measure of consumer surplus. Analysts have expressed concerns that respondents may imply the value of the good from the starting value in the bid process. The vulnerability to this problem, called starting point bias, has caused researchers to limit use of the bidding game as a contingent valuation elicitation method (Cummings, Brookshire, and Schulze, 1986; Mitchell and Carson, 1989).

The bidding game elicitation method presents a range of values of potential willingness to pay amounts from zero to some large amounts (Bergstrom, Dillman, and Stoll, 1985; Welsh and Poe, 1996; Jordan and Elngaheeb, 1994). This method, developed by Mitchell and Carson in 1984, provides assistance to respondents in selecting a willingness to pay amount in a format amenable to personal and mail interviews but inappropriate for telephone interviews. However, the ranges presented in the payment card provide another potential source of bias (Mitchell and Carson, 1989).

The dichotomous choice format elicits willingness to pay by asking the respondent to provide a "yes" or "no" response to a fixed dollar amount (Bowker and Stoll, 1988; Hagen, Vincent, and Welle, 1992; Stevens, *et al.*, 1991; Whitehead and Blomquist, 1991). Also called the referendum or take-it-or-leave-it elicitation format, this method is often more familiar to individuals who decide their willingness to pay for consumer goods and other commodities in response to a fixed price assigned to the item (Arrow, *et al.*, 1993). It is also similar to referendum voting in which individuals vote for or against taxes, fees, or other vehicles in order to finance the provision of a public good.

Although the dichotomous choice format is less vulnerable to strategic bias than other elicitation forms (Arrow, *et al.*, 1993), it may suffer from starting point bias, a problem which can be hard to detect with this format (Mitchell and Carson, 1989). Another issue associated with this format is the possibility that the respondent may express a positive response to an amount presented on the questionnaire which exceeds their willingness to pay. The respondent may reply with an inaccurate "yes" response to the contingent valuation question because he or she lacks the time or motivation to consider the true value of the amenity (Bishop and Heberlein, 1979; Cummings, Brookshire, and Schulze, 1986), because it is costless to supply an inaccurate answer (Kealy and Turner, 1993; Freeman, 1979), or because the respondent engages in "yea-saying", supplying a response based upon what he or she believes that is the desire of the survey administrator or sponsor (Arrow, *et al.*, 1993).

The dichotomous choice format is relatively inefficient compared to other elicitation methods, as estimation of willingness to pay requires a relatively larger sample size. Also, it does not provide an actual maximum willingness to pay but rather a discrete indicator maximum willingness to pay. Estimates of willingness to pay are modeled by fitting a logistic or probit regression curve to the percentage of respondents who are willing to pay a given random amount (Mitchell and Carson, 1989).

The double bounded dichotomous choice format, also called the take-it-or-leave-it with follow-up, is a variation designed to overcome some of the inefficiency associated with the dichotomous choice format. In this method, after the first dichotomous choice question, the respondent is asked a second dichotomous choice question asking willingness to pay a larger fixed amount (in the event of a positive response) or a smaller specified amount (in case of a negative response) (Mitchell and Carson, 1989). It is more efficient and precise than the ordinary dichotomous choice format (Cooper, 1993) and can help set a lower bound for willingness to pay (Champ, *et al.*, 1996). The double bounded dichotomous choice method is also more complex than the single bounded dichotomous choice format and is more susceptible to response bias, namely "yea saying" (McLoed and Bergland, 1996).

Many researchers have noted a difference in the values obtained from contingent valuation instruments employing different elicitation formats. The dichotomous choice format usually provides higher WTP estimates than either the open-ended format (Kealy and Turner, 1993; Brown, *et al.*, 1996) or the payment card format (Jordan and Elngaheeb, 1994; Welsh and Poe, 1996). The open-ended format is less often used in recent research.

Although the payment card method has been indicated as more efficient than the dichotomous choice method (Jordan and Elngaheeb, 1994), many researchers prefer the dichotomous choice method because it is comparatively simpler and less vulnerable to strategic bias (Hoehn and Randall, 1987; Mitchell and Carson, 1989). This research employs the single bound dichotomous choice elicitation format in the estimation of the passive use values for biodiversity.

Framing the Valuation Question

To obtain an empirical measure of the value of biodiversity, this research has focused on the terrestrial local biodiversity (α-diversity) within an area of a larger ecosystem, the Lower Mississippi River Valley. The Lower Mississippi Valley, also known as the Lower Mississippi Alluvial Plain, is a geographical region stretching 600 miles from the confluence of the Mississippi and Ohio Rivers at Cairo, Illinois, to New Orleans, Louisiana, covering twenty-six million acres in seven states. Because of the scope of the Lower Mississippi Valley and the lack of a single integrated preservation plan for the entire ecosystem, the value of the biodiversity in the entire region, the γ-diversity, is beyond the scope of non-market valuation techniques.

This research has examined the passive use value of the Tensas River basin in northeastern Louisiana. The study area is one of the last contiguous stretches of the bottomland hardwoods ecosystem that once covered a vast area of the North American continent. The Tensas River basin's prime bottomland hardwood sites are some of the few remaining in the United States and its wetlands are some of the most important in the country (Figure 3.3). They provide prime over-wintering grounds for many neo-tropical

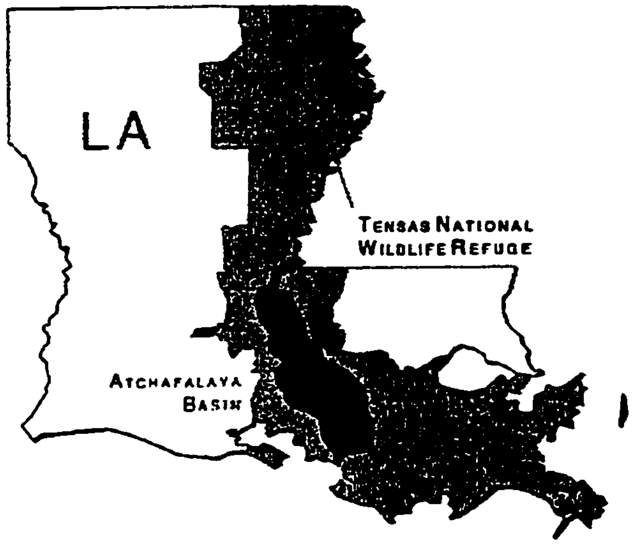

Figure 3.3 The Lower Mississippi Valley in Louisiana and The Tensas River Basin

bird species. Located along the Mississippi Flyway, it provides habitat for many game bird species including mallards, wood ducks, and turkeys. The wetlands are important as spawning and nursery grounds for many species of finfish. The hardwoods also supply the habitat of numerous species of wildlife including squirrel, deer, raccoon, mink, beaver, fox, and rabbit (U.S. Natural Resource Conservation Service, 1995; Creasman, Craig, and Swanson, 1992).

This region forms part of the proposed critical habitat for the threatened Louisiana black bear (*Ursus americanus luteolus*) and neotropic bird species. Other animal species found in the Tensas River basin include deer, squirrel, rabbit, various waterfowl and numerous fish species. In addition, the area contains several botanical species, including hardwoods, oaks, sweetgums, pecans, cypress, and drummond red maples (U.S. Natural Resource Conservation Service, 1995).

Like most of the Lower Mississippi Valley, the expansion of agriculture, housing, and other forms of human development is diminishing the quantity and quality of land suitable for wildlife habitat (U.S. Fish and Wildlife Service, 1994a). Several conservation programs have been established to protect natural habitat in the area. The Wetlands Reserve Program and Partners for Wildlife provide incentives for private landowners to preserve wildlife habitat (U.S. Fish and Wildlife Service, 1995). The Big Lake Wildlife Management Area, a wildlife recreation area administered by the state of Louisiana, covers 19,200 acres in the region for the benefit of game and other wildlife and plant species (U.S. Natural Resource Conservation Service, 1995). The largest area of preserved habitat in the basin is covered by the 63,925-acre Tensas River National Wildlife Refuge, a hunting, timber, and wildlife preserve ("An Act to Establish the Tensas River National Wildlife Refuge", 1980; U. S. Fish and Wildlife Service, 1995). The presence of these and other conservation mechanisms can facilitate efforts to maintain biodiversity in the region.

The Tensas River basin section of the Lower Mississippi Valley ecosystem is considered an important although not exotic natural resource. It is a habitat type that is familiar to many people who may have had no personal experience with the area. While containing hundreds of different species, it is not considered to have a high degree of biodiversity in comparison to more exotic ecosystems which may contain millions of different species (Brown, 1996). The familiarity of the resource to potential survey respondents and the relatively limited scope of biodiversity should reduce some of the uncertainty surrounding valuation estimation.

Because biodiversity is a complex commodity, efforts were made to present the commodity in terms comprehensible to the respondent. The biological diversity in the Tensas River valley area within the Lower Mississippi Valley ecosystem was described using the concept of "ecological endpoints" (Kiker, 1996) which focus on certain key component of biodiversity. These key components can act as indicators of the condition of biodiversity within an ecosystem. For example, Simpson, Sedjo, and Reid (1996) estimated pharmaceutical companies' option values for various rainforests by using the taxon of higher level plants as an indicator of biodiversity within these ecosystems.

In the Lower Mississippi River Valley, birds serve as a preferred indicator for terrestrial biodiversity (Pashley, 1997). The diversity of bird species indicates an increase in the number of other species in the ecosystem. From a management perspective, however, the number of bird species present within the area is not necessarily a meaningful indicator of the ecological well-being of other species. Because many of the most vulnerable bird species within the ecosystem are migratory, the cause of population fluctuations may be attributable to factors outside the Lower Mississippi River Valley ecosystem. Wildlife scientists managing natural resources for the benefit of biological diversity can instead use as an indicator for biodiversity only the available acreage of contiguous bottomland hardwoods forest (Ester, personal communication). While it hypothesized that the number of species present within an ecosystem is a function of the area devoted to natural habitat (equation 2.3), it is not possible to fix an exact number of species from a precise equation.

In estimating the required area of preserved habitat, wildlife scientists have identified an umbrella species whose habitat needs could act as a proxy for biological diversity in the basin (Patlis, 1996). Wildlife scientists and managers are able to estimate the quantity of bottomland hardwoods that would be required to maintain the biological diversity within the Tensas River basin by preserving land sufficient to maintain a meaningful population of a species of neotropical bird with large range requirements. Wildlife scientists calculate that the 100,000 acres of forested wetlands that would support the swallow-tailed kite (*Elanoides forficatus*) would be enough to support the diversity of plant and animal species within the ecosystem (Hamilton, 1997). The management program can be interpreted as enlargening the boundaries of the protected area within the Tensas River basin to coincide with the biotic boundaries needed to maintain a minimum viable population of the species within the ecosystem (Newmark, 1985; Snape, 1996a).

This framing method for biodiversity is somewhat limited by the lack of knowledge within the scientific and management community on the effectiveness of habitat preservation in preserving aquatic biodiversity. The policies which preserve terrestrial biodiversity in the Tensas River basin, while significantly improving conditions for aquatic plants and wildlife, are not expected to be as successful for aquatic biodiversity. Aquatic diversity is influenced by a number of environmental factors which do not have as strong an influence on terrestrial biodiversity (Vidrine, 1996; Costanza, Kemp, and Boynton, 1995). Preservation efforts aimed at aquatic biodiversity must focus on a different set of factors, including water flow adjustments, water quality improvement and agricultural run-off reduction. Wildlife managers have not identified a bioindicator species for aquatic diversity in the Tensas River basin.

The valuation of terrestrial biodiversity is framed in terms of the structural species, bottomland hardwoods trees, an umbrella species, the swallow-tailed kite, and habitat area required to maintain the diversity of species within the ecosystem. By focusing on specific habitat acreage in a particular location, the passive use valuation of biodiversity is framed in a manner similar to previous nonmarket valuation estimates of the benefits of single species which also focus on habitat preservation (Bowker and Stoll, 1988; Stoll and Johnson, 1989; Rubin, Hefland, and Loomis, 1991; Stevens, *et al.*, 1994; Hagen, Vincent, and Welle, 1992; Reaves, *et al.*, forthcoming). While other contingent valuation studies have estimated the value of preserving ecosystems (Whitehead and Blomquist, 1991; Dillman, Beran, and Hook, 1993), the framing of this valuation estimate is actually more precise by specifically eliciting the willingness to pay for a particular function, the preservation of biological diversity, of the ecosystem.

Data Collection

The conceptual model for the valuation of the passive use values of biodiversity as presented in equation (3.2) was estimated using data collected via a mail survey conducted by the Louisiana State University Department of Agricultural Economics and Agribusiness in accordance with Dillman's Total Design Method (TDM) (1991). The TDM recommends particular questionnaire format and mailing procedures to improve response rate and response quality. The questionnaire (Appendix A) included both open and closed format questions.

Survey Sample

The survey was sent to a sample of identified outdoor recreators and an additional sample including individuals who were not *a priori* identified as users of the ecosystem. The outdoor recreationist group consisted of 1,400 individuals whose names were selected from 3,169 applicants in a hunting permit lottery system operated by the Tensas River National Wildlife Refuge located within the Tensas River basin near Tallulah, Louisiana. The outdoor recreationist sample was identified only as potential consumptive users of the Tensas River basin because only a minority of the individuals whose names were included in the lottery were actually allotted hunting permits. This sample was included in this research as a sample of individuals who may possess more extensive personal knowledge of the ecosystem than the population at large. Many of the individuals who paid the service fee to be included in the Tensas River National Wildlife Refuge lottery were hypothesized to be familiar with the Tensas River basin and other portions of the Lower Mississippi Alluvial Plain. This sample is labeled as the Tensas lottery sample.

In addition to the Tensas lottery sample, another sample, labeled the general population was included. This group, not identified as a outdoor recreationist group, was drawn from an additional sample of 3,395 persons randomly drawn from 1997 telephone directories of Louisiana and contiguous counties in Arkansas and Mississippi. These three states were included in the survey sample because sections of these states are included in the Lower Mississippi Valley and because they are adjacent to the Tensas River basin. As a result, a fuller measure of the passive use values, which may extend beyond political boundaries, was obtained by including in the sample residents of states other than that which physically contains the environmental amenity.

Survey Administration

The first mailing sent to both samples included a questionnaire, a postage-paid return envelope, and a letter identifying the purpose of the survey and the proposed application of the data collected (Appendix A). The second mailing, distributed approximately two weeks after the first mailing, sent a postcard to all those in the sample thanking responders and reminding those who had not of the importance of responding to and returning the questionnaire. The third mailing, mailed approximately one month after the first mailing, was directed to those who had not responded to the survey. It consisted of a letter reiterating the importance of responding to the survey, another copy of the original survey, and an additional postage-paid return envelope.

Questionnaire Design

The survey was divided into six sections designed to provide data for estimation of the valuation model and provide additional contextual information. The first section assessed the respondent's participation in outdoor recreation. Outdoor recreationists, due to personal experience with and demonstrated preference for natural amenities, were hypothesized to have a differing value for environmental amenities, including biodiversity. The first question, Q-1, elicited the individual's participation in thirteen forms of outdoor activities, including both consumptive recreational activities, such as hunting and fishing, and non-consumptive recreational activities, including bird watching, photography, camping, hiking, and recreational vehicle operation. Recreationists who participate solely in consumptive activities are likely to demonstrate passive use values which are distinct from those of solely non-consumptive recreationists. Of consumptive recreationists, anglers may hold different passive use values than hunters. Among non-consumptive recreationists, those who participate in activities such as water-skiing and all-terrain vehicle and jet-ski operation may possess passive use values which different from participants in relatively passive forms of recreation such as photography, canoeing, or hiking.

Additional subsections were designed to elicit more information regarding participants in hunting, fishing, and non-consumptive recreationists including self-reported proficiency levels (questions Q-2, Q-5, and Q-8), ownership or management of the participation site (Q-3, Q-6, and Q-11), and the state or states of participation (Q-4, Q-7, and Q-10). Questions were also included to elicit the individual's participation in outdoor recreation within two parks within the Tensas River basin: the Big Lake Wildlife

Management Area managed by the Louisiana Department of Wildlife and Fisheries (Q-11) and the Tensas River National Wildlife Refuge managed by the U.S. Fish and Wildlife Service (Q-12 and Q-13). Respondents were also asked to rate the importance of seven consumptive and non-consumptive activities at the Tensas River National Wildlife Refuge (Q-14). These questions, in conjunction with the identification of the Tensas lottery sample, are used to differentiate users and nonusers of the Tensas River basin.

Section 2 elicited the respondent's views on a variety of public issues, including environmental topics. Question Q-15 requested the respondent's priority ranking on a four-point Likert scale from very low to very high priority of five issues: improving health care, cutting government spending, lowering crime rates, improving education, and protecting the environment. Adapted from a survey on the understanding of biodiversity conducted by Belden and Russonello (1995), this question was designed to test the relative importance of environmental protection among a number of alternative issues presented to the respondent. Based on previous research, rankings on this scale were expected to be comparatively low (Belden and Russonello, 1995; Ladd and Bowman, 1996).

Question Q-16 was designed to elicit the respondent's perception of the current state of the U.S. environment. Persons who believe that the condition of the environment is growing worse may be willing to pay more to preserve environmental amenities such as biodiversity than those who believe it is improving or staying the same. Question Q-17 also requests a four-point Likert scale ranking from "Not Important At All" to "Very Important" of a number of different environmental issues. The intention of this question was to allow respondents to rate the importance of habitat preservation among other environmental concerns (Belden and Russonello, 1995).

Three questions were designed to elicit the respondent's familiarity with the concept or meaning of the term biodiversity (Q-18), the rate of biodiversity loss (Q-19), and the cause of extinction (Q-20). These three questions are adapted from Belden and Russonello (1995) and designed to measure the respondent's familiarity with biodiversity and the impact of human activity upon extinction rates. If respondents are not familiar with issues of biological diversity and extinction, willingness to pay figures derived may not be reliable measures for the value of passive use of habitat preservation (Arrow, *et al.*, 1992).

Section 3 elicited the respondent's willingness to pay to preserve biodiversity in the Tensas River area of the Lower Mississippi River Valley. The valuation question, Q-21, asks whether the respondent is willing to pay each year into a voluntary fund designed to increase the protected acreage of bottomland hardwoods from the currently protected 88,000 acres (the combined total of the Tensas River National Wildlife Refuge and the adjacent Big Lake Wildlife Management Area) to 100,000 acres. The relationship between an increase in habitat area and number of species was explained. The questionnaire described 100,000 acres as the quantity deemed by scientists as sufficient to support the diversity of plant and animal species within the Tensas River basin. While the valuation question mentioned the use of the range requirements of a particular bird species as a rule of thumb for acreage requirements, the questionnaire did not mention the identity of the bird species to avoid eliciting a valuation of the bird itself rather than the diversity its habitat supports.

The question is framed in the dichotomous choice form asking a particular closed response, "yes", "no" or "I am not certain", to a specified amount, drawn at random, ranging from $1, $5, $10, $25, $50, $100, and $150. These amounts were selected by reference to previous research in ecosystem and habitat preservation and confirmed in a pretest. Pretesting is important in identifying and addressing possible sources of bias and other problems with the survey design. Pretesting was also useful in establishing the relevant range of the dollar values in this survey (Reaves, 1994; Loomis, *et al.*, 1990; Loomis and White, 1995). The response "I am not certain" was included in compliance with the recommendation of the NOAA Blue Ribbon Panel to include a "no answer" option (Arrow,*et al.*, 1993). The "I am not certain" responses will be combined with the "no" responses in the econometric model which will estimate the probability of giving a "yes" response to an amount given in the dichotomous choice question (Randall, 1997).

Following the single bound dichotomous choice willingness to pay questions were two close ended questions asking the respondent for the reason he or she responded to the previous question with a negative (Q-22) or positive response (Q-23). The reasons for negative responses included those arising from primarily economic motives and those stemming from other motives. The economic negative responses included placing a zero value on habitat preservation, placing a smaller non-zero value on habitat preservation than that presented in the dichotomous choice question, and being unable to afford a donation of the amount included on the questionnaire. The reasons for a positive response were designed to determine if the response was subject to the warm glow or embedding problems described by Kahnemann and Knetch (1992) (Arrow, *et al.*, 1993; Reaves, *et al.*, forthcoming).

Section four presented the New Ecological Paradigm (NEP), a scale designed to provide a measure of the respondent's environment attitude (Dunlap, *et al.*, 1992). The NEP is a revision of the New Ecological Paradigm, a twelve question scale developed by Van Liere and Dunlap (Dunlap and Van Liere, 1978; Van Liere and Dunlap, 1980). The section consists of fifteen questions to which the respondent is asked to indicate agreement ("Strongly Agree" or "Agree"), disagreement ("Disagree" or "Strongly Disagree") , or indifference ("Undecided").

Eight questions are worded such that agreement indicates a pro-environmental attitude. For these questions, the response is scored from one to five on a Likert scale, with "Strongly Disagree" equal to one and "Strongly Agree" equal to five. Alternating with these eight "pro-environmental" questions are seven questions for which disagreement indicates a pro-environmental attitude. For these seven "anti-environmental questions", the Likert scale scoring was reversed.

The measure of environmental attitude is compiled by summing the scores of the pro-environmental questions and the rescaled scores of the anti-environmental questions (Arcury, 1990; Dunlap, *et al.*, 1992). The NEP may be more reliable than measures by proxy of such characteristics as membership in an environmental organization, a sometimes nebulous designation which includes a wide spectrum of organizations with widely varying goals and purposes. Individuals who are scored as having an attitude more sympathetic towards environmental preservation were hypothesized to have larger passive use values for biodiversity than those who scored as having less sympathetic inclinations.

The fifteen question NEP can be divided into sections which provide a measure of the respondent's attitudes towards five factors, or domains, of the global environmental world view. These five factors include the possibility of ecological crisis, fragility of the balance of nature, limits to growth, anti-anthropocentrism, and the rejection of human exceptionalism (Table 3.2). An individual may possess a pro-environmental attitude towards one facet of the environmental world view but not for another (Dunlap, *et al.*, 1992). Willingness to pay for the preservation of biodiversity may be positively correlated with one of the factors but not with another. It is hypothesized that of the five factors those dealing with limits to growth, the fragility of the balance of nature, and the possibility of ecological collapse would be most significant to the valuation of biodiversity.

Section five elicited the respondent's socioeconomic characteristics. Question Q-25 asked for the respondent's gender in a closed format. Question Q-26 was a closed format question asking the respondent to identify the highest level of education completed, ranging from grade school to advanced college degree. Question Q-27 is a closed-format question requesting the identification of respondent's racial or ethnic background. Question 28, designed to test the influence of place of residence on the passive use value of biodiversity, asked for the best description of the respondent's place of residence with responses ranging from farm residence to central cities or suburbs of central cities of over 50,000 residents. Because age was hypothesized to have an influence on the respondent's passive use value for biodiversity, the respondent was asked in an open-format question,

Table 3.2 Factors Included in the New Ecological Paradigm

Factor 1. Limits to Growth (Q24-1, Q24-6, Q24-11)	
1.	We are approaching the limit of the number of people the earth can support.
6.	The earth has plenty of natural resources if we just learn how to develop them.
11.	The earth is like a big spaceship with very limited room and resources.
Factor 2. Anti-Anthropocentricism (Q24-2, Q24-7, Q24-12)	
2.	Humans have the right to modify the natural environment to suit their needs.
7.	Plants and animals have as much right as humans to exist.
12.	Humans were meant to rule over the rest of nature.
Factor 3. Fragility of the Balance of Nature (Q24-3, Q24-8, Q24-13)	
3.	When humans interfere with nature it often produces disastrous consequences.
8.	The balance of nature is strong enough to cope with the impacts of modern industrial nations.
13.	The balance of nature is very delicate and easily upset.
Factor 4. Rejection of Exceptionalism (Q24-4, Q24-9, Q24-14)	
4.	Human ingenuity will ensure that we do NOT make the earth unlivable.
9.	Despite our special abilities, humans are still subject to the laws of nature.
14.	Humans will eventually learn enough about how nature works to be able to control it.
Factor 5. Possibility of Ecological Collapse (Q24-5, Q24-10, Q24-15)	
5.	Humans are severely abusing the environment.
10.	The so-called "ecological crisis" facing humankind has been greatly exaggerated.
15.	If things continue on their present course, we will soon experience a major ecological catastrophe.

Source: Dunlap, *et al.*, 1992.

Q-29, to provide his or her present age in years. Respondents were asked in an open-format question, Q-30, to give the number of people, including the respondent, living in the household.

The following question, Q-31, asked for the number of persons under the age of eighteen residing in the household. It was hypothesized that larger households may reflect either a positive or negative influence on the passive use value for biodiversity. Individuals with larger families may value biodiversity more highly as a result of more altruistic attitudes fostered in a large family environment. Alternatively, such individuals may value biodiversity less because of comparatively restrictive budget constraints which indicate that funds must be diverted to other goods and amenities. Households with children under the age of eighteen may have a comparatively large bequest value, which could have a positive effect on passive use values overall. A competing hypothesis may be supported because households with children under the age of eighteen may have less money available to pay for environmental amenities. The final question in the questionnaire asked the respondent to give the range of income which best describes his or her income. The seven ranges provided correspond to ranges defined by the United States Census Bureau (U.S. Census Bureau, 1992). The use of these ranges allows a comparison of the respondent sample with the population characteristics of the three states included. This question was designed to test whether passive use value for biodiversity is a normal good like other environmental amenities (Panayotou, 1993).

Survey Summary Statistics

Of the 4,795 surveys mailed, 400 surveys were not deliverable due to the relocation, incapacitation, death, or imprisonment of the intended recipient. Within the different samples, 351 surveys in the general population sample and 49 surveys in the Tensas lottery sample were not deliverable, reducing the sample size of the former to 3,044 and of the latter to 1,351. The final sample size was 4,395.

Of the 4,395 surveys mailed and deliverable, 1,580 were returned for an overall response rate of 36.0 percent. Of the total, 942 surveys, 59.6 percent, were returned from the general population sample, a subsample return rate of 30.0 percent. The remaining 638 surveys were returned from the Tensas lottery sample, a 47.2 percent return rate. The summary statistics and frequency tables for the 1,580 surveys returned are included in Appendix C.

The respondents to the survey were predominately male, 83.0 percent in the combined sample, 96.2 percent in the Tensas lottery sample, and 73.0 percent in the general population sample. Of the survey respondents, 91.4 percent were white, a disproportionate representation of the white population of the three states included in the survey, Louisiana (67.3 percent), Arkansas (82.5 percent), and Mississippi (63.1 percent). While the average resident age of Louisiana is 31.0, Arkansas, 33.8, and Mississippi. 31.1 years, the average age in the combined sample was 46.6 years. The average age of the Tensas lottery sample respondent was 39.9 years and of the general population sample 51.2 years.

While only 5.2 percent of Louisiana households, 3.7 percent of Arkansas households, and 3.7 percent of Mississippi households earned income in excess of $75,000

While only 5.2 percent of Louisiana households, 3.7 percent of Arkansas households, and 3.7 percent of Mississippi households earned income in excess of $75,000 in 1989 (U.S. Bureau of the Census, 1990), 14.6 percent of the combined sample, 8.9 percent of the Tensas sample, and 19.5 percent of the general population sample reported 1996 income greater than $75,000. Conversely, while 36.3 percent of Louisiana, 35.9 percent of Arkansas, and 39.2 percent of Mississippi households earned incomes less than $15,000 in 1989 (U.S. Census, 1990), only 9.9 of the combined sample, 5.9 percent of the Tensas lottery sample, and 12.7 of the general population sample reported incomes beneath this level in 1996.

While the proportion of the combined sample living in rural areas or in towns of less than 10,000 (40.3 percent) was roughly equivalent to the percentage in Louisiana (42.2 percent), the Tensas lottery sample was over-represented by (64.9 percent) and the general population under-represented (23.3 percent) by residents of such areas. The sample was also distinguished by more years of formal education than the average resident of Louisiana. While only 16.1 percent of Louisiana residents, 13.3 of Arkansas residents, and 14.7 percent of Mississippi residents have at least a Bachelor's degree (U.S. Bureau of the Census, 1990), 30.9 percent of the combined sample, 20.8 percent of the Tensas lottery sample, and 37.9 percent of the general population sample has achieved at least this level of education.

The survey sample includes a larger percentage of hunters and fishers than the population of the states included in the survey. While only 28 percent of Louisiana residents, 32 percent of Arkansas residents, and 31 percent of Mississippi residents reported hunting or fishing in 1991 (U.S. Department of the Interior, 1993), 55.6 percent of the general population sample and 99.1 percent of the Tensas lottery sample participated in these forms of outdoor recreation in 1996.

Priority of Environmental Protection and Familiarity with Biodiversity Issues

The results of the question Q-15 indicate that protecting the environment is not a top priority for this sample. This question used a four point Likert scale, where values of one were given to "lowest priority" and values of four to "highest priority." The priority assigned to each of five issues were ranked by comparing the average Likert scale priority values as well as the percentage of respondents assigning "highest priority" status for each issue. By both standards, the priority assigned to protecting the environment was ranked below that of reducing crime rates and improving education. This is consistent with the findings of previous research regarding the prioritization of ecological or environmental protection among other concerns (Belden and Russonello, 1995; Ladd and Bowman, 1996).

The majority of the respondents from both samples expressed a belief that overall the environment was improving. Of the Tensas lottery sample, 53.5 percent believed that overall, the environment was improving a great deal or somewhat versus 30.3 who believed environmental conditions were getting somewhat or a great deal worse. Somewhat less pessimistic was the general population sample 55.8 percent of whom thought that the environment overall was improving and 24.6 percent of whom thought it was getting worse.

Among environmental issues, the importance assigned by respondents to nine separate environmental issues was elicited in question Q-17. Two of the environmental issues were related to biodiversity: the rate at which natural places are being lost and the rate at which plants and animals are going extinct. The loss of rainforest is also related to the condition of biodiversity but is distinguished by being specifically an international issue or foreign concern. Concern for foreign environmental issues is often less than concern for domestic environmental issues (Belden and Russonello, 1995).

In both the Tensas lottery sample and the general population sample, the average Likert scale value and the percentage of respondents giving a "very important" ranking to the biodiversity related issues were less than those for water quality, air quality, and toxic waste. In the Tensas lottery sample, both the development rate and extinction rate received higher importance scores than loss of rainforest, overconsumption of resources, acid rain, and global warming. The importance assigned to each of the environmental issues by the general population sample lagged behind the Tensas lottery sample. In the general population sample, importance of the rate of development of natural areas was greater than the importance of the extinction rate. Different measures of the importance of the loss of wild places and the rate of extinction suggest that respondents do view the two issues separately and are relatively less concerned about species extinction.

While only a minority of both the Tensas lottery (40.2 percent) and the general population (34.4 percent) sample had heard of the term "biodiversity", a majority of both samples were aware of factors related to biodiversity. A majority of the Tensas lottery (65.3 percent) and the general population (70.3 percent) sample were aware of the decline of the number of plant and animal species. The majority of both samples had at least some awareness of the role of human activities as the primary cause of the accelerated rate of plant and animal species extinctions (Wilson, 1992; Huston, 1994). Of the combined sample, a majority (54.4 percent) identified "mostly human actions" and an additional 35.1 percent identified "natural causes and human causes about equally" as the main reason that plant and animal species become extinct.

Relationship to NOAA Guidelines

The design and implementation of the survey used in this research was constructed with reference to the recommendations of the NOAA Blue Ribbon panel. This body, chaired by two Nobel laureate economists, evaluated the contingent valuation method. The NOAA panel issued a conditional endorsement of the contingent valuation method and defined standards required to establish the reliability of contingent valuation surveys. The specific recommendations include general sampling and reporting guidelines, value elicitation guidelines, and burden of proof requirements (Arrow, *et al.*, 1993; Carson, *et al.*, 1993). The NOAA panel recommendations were established to ensure dependability of contingent valuation for use in mitigation, litigation, and other governmental, legal, and financial situations. Although certain of the NOAA recommendations have been criticized for a variety of reasons (Randall, 1997), the comparison of the survey structure and results to the NOAA Panel recommendations provides a measure of its reliability.

The general survey guidelines include sample size and type, minimization of non-response bias, personal interview, pretesting, and reporting of survey results. Financial constraints necessitated the substitution of a mail survey for the preferred personal interview data collection method. Although mail surveys are characterized by a higher non-response rate than telephone or personal interviews, the 30.0 percent response rate for the general population sample and the 47.2 percent response rate for the Tensas sample are acceptable for mail surveys. The questionnaire was pre-tested by a group of twenty-five individuals to identify possible sources of error, misunderstanding, and confusion as well as establish the relevant ranges of dollar values in the contingent valuation question. The questionnaire and survey results are reported in appendix A.

In compliance with the NOAA standards, the contingent valuation survey followed a conservative design and employed a willingness to pay elicitation in the dichotomous choice format. In addition to "yes" and "no" vote options, a "no answer" option was included. Follow up questions elicited the reasons for a "yes" or "no" response. The questionnaire included an accurate description of the biodiversity conservation program in the Tensas River, focusing on the relationship between the protection of habitat sufficient for an umbrella species and the maintenance of the variety of plant and animal species. Respondents were reminded that the focus region, the Tensas River basin, was only one part of a larger ecosystem, the Lower Mississippi River Valley, within which substitute habitat existed.

In accordance with the NOAA guidelines, the survey also included questions to help interpret the responses to the valuation question. These included income, general environmental attitudes, attitudes regarding factors contributing to the condition of biological diversity, and attitudes towards other public issues. As a check on understanding, additional questions elicited knowledge of the term "biodiversity", the acceleration in the extinction rate, and the role of human actions affecting the extinction rate. Other NOAA guidelines, adequate time lapse from the accident and temporal averaging, were not relevant to the topic of this survey because the valuation did not involve the restoration of an environmental amenity following a damaging incident.

This research also addressed the goals for value elicitation surveys described by the NOAA Panel. As a reminder of that the respondent's willingness to pay for the conservation of biodiversity habitat would reduce expenditures for other goods, the respondent was asked to pay the dollar amount from his or her household budget. The survey was designed to deflect the "warm glow effect" and focus on the environmental benefits of the specific biodiversity conservation program in a particular location, the Tensas River basin. The follow-up question for the "yes" responses included replies intended to detect the presence of "warm glow" responses given by respondents. The follow-up question for the "no" responses were designed to detect the presence of "protest" votes and other reasons which did not address the value of the biodiversity conservation program being evaluated.

The NOAA Panel guidelines also include conditions for the burden of proof which this survey addressed: non-response rate, inadequate responsiveness to scope of environmental damage, lack of understanding or believability, and lack of follow-up questions to "yes" and "no" votes. The survey was not marked by a high non-response rate to the survey instrument or valuation question. The survey sample was also characterized by an adequate understanding of the increase in the extinction rate, the contribution of human actions to this increase, and the importance of maintaining habitat and natural areas for the conservation of species. Follow up questions elicited the reasons for positive and negative responses to the valuation question, distinguishing economic reasons, warm glow responses, and protest votes.

Unfortunately, the survey was not able to include a measure of the responsiveness to the scope of environmental damage due to the lack of a realistic program which would have permitted such a measure. Eliciting the willingness to pay for a larger area may have provided a measure of responsiveness to scope. Such an increase would not necessarily have contributed to an improvement in species diversity. The relationship between a further increase in habitat size and species diversity has not been established. Although the inclusion of wildlife corridors as an additional biodiversity conservation program may have provided an opportunity for measuring the respondents' responsiveness to scope, such a program may have confused the concept of local species diversity with inter-ecosystem species and genetic diversity that wildlife corridors are designed to augment. The lack of a measure of responsiveness to scope resulting from the lack of a realistic and relevant program may reduce the reliability of the survey results.

The following chapter presents empirical models derived from the conceptual models discussed in chapter III. Empirical estimation techniques and results for estimation of the value of preserving habitat for the biological diversity represented in the Tensas River basin are discussed.

Chapter IV.

Empirical Analysis

Introduction

The empirical analysis of the dichotomous choice willingness to pay elicitation format used in this research requires the application of qualitative dependent variable econometric models. This chapter presents the econometric model as well as the definition of an economic model for the estimation of passive use values of the preservation of biodiversity habitat in the Tensas River basin. This chapter also defines the sample which can be used to measure passive use values. In addition, this chapter extends the qualitative dependent variable analysis beyond the binary choice model used in previous research to analyze the factors contributing the selection of three decision alternatives, yes, no, and uncertain.

Definition of Sample Groups

This section refines the definition of the sample groups to be used in the econometric analysis of the passive use value of biodiversity. Following Mitchell and Carson (1989) and Silberman, Gerlowski, and Williams, (1992), it is hypothesized that willingness to pay estimates for nonusers may be larger than those for nonusers of the Tensas River basin. This difference may be attributable to the inability of users accurately to supply willingness to pay estimates for passive use values which are completely isolated from use values. Evidence of the spillover of use values into passive use value estimates include differences in model parameter estimates and larger willingness to pay estimates for the user group.

This research defines the user group as all respondents who used or intended to use the Tensas River basin in 1996. All respondents drawn from the Tensas lottery sample are included in this group, regardless of having actually visited the basin in the sample year, because they demonstrated a use value for the resource by placing their names in the lottery. In addition, all respondents from the general population sample who reported visiting either the Tensas River National Wildlife Refuge or the Big Lake Wildlife Management Area are included in the user group. The nonuser group includes all respondents from the general population sample who did not report visiting the Tensas River basin in 1996.

Empirical Models

The estimation of the passive use value of biodiversity is based upon the utility function for the ith individual,

$$U_i(x, S), \tag{4.1}$$

in which x represents a numeraire or bundle of market goods and S, a measure of species diversity. Although the individual is assumed to know his or her preferences with certainty, the econometric observer can not observe all components of the utility function. The unobservable components are treated as stochastic. The level of utility for individual I under choice j, $U_{ij}(x, S_j)$, $j = 0,1$, associated with the condition of species diversity S_j is a random variable with mean $V_{ij}(x, S_j)$ and stochastic error, ϵ_{ij}:

$$U_{ij}(x, S_j) = V_{ij}(x, S_j) + \epsilon_j \tag{4.2}$$

(Hanemann, 1984; Judge, *et al.*, 1988). In a dichotomous choice contingent valuation willingness to pay scenario, the individual is presented with two alternatives. The first alternative is consume the same quantity of the numeraire and the existence good:

$$U_{i1}(x, S_1) = V_{i1}(x, S_1) + \epsilon_{i1} \qquad (4.2a).$$

The second alternative is to consume a dollar amount \$B less of the numeraire in exchange for an increase in the provision of the existence good:

$$U_{i2}(x, S_2) = V_{i2}(x\text{-}\$B, S_2) + \epsilon_{i2} \qquad (4.2b),$$

where \$B is a randomly selected dollar amount presented on individual I's questionnaire.

The ith individual will select alternative 2 only if $U_{i2} > U_{i1}$. An individual who is presented a request to pay \$B to increase species diversity from S_1 to S_2 will pay the amount only if

$$V_{i2}(S_2, x - B) + \epsilon_{i2} \geq V_{i1}(S_1, x) + \epsilon_{i1} \qquad (4.3).$$

The individual's response is a random variable with the following probability density function:

$$P_1 \equiv \Pr\{\text{individual I is willing to pay}\} =$$

$$\Pr\{V_{i2}(S_2, x - B) + \epsilon_2 \geq V_{i1}(S_1, x) + \epsilon_1\} \qquad (4.4)$$

$$P_0 \equiv \Pr\{\text{individual is unwilling to pay}\} = 1 - P_1.$$

The first equation in (4.4) can be reorganized as:

$$P_1 \equiv \Pr\{V_{i2}(S_2, x - B) - V_{i1}(S_1, x) \geq (\epsilon_{i2} - \epsilon_{i1})\} \qquad (4.4a)$$

$$= \Pr\{\Delta V \geq \eta\},$$

where $\Delta V \equiv V_{i2}(S_2, x - B) - V_{i1}(S_1, x)$ and $\eta \equiv \epsilon_{i2} - \epsilon_{i1}$.

The difference in the error terms, η, is distributed with cumulative density function $F_\eta(\bullet)$. The probability of willingness to pay can be written as:

$$P_1 = F_\eta(\Delta V) \tag{4.4b}$$

In the probit model, this c.d.f. has a normal distribution. The c.d.f. follows a logistic distribution in the logit model (Hanemann, 1984, 1989; Madalla, 1983).

These models yield comparable results (Capps and Kramer, 1985; Amemiya, 1981); however, the assumptions of a c.d.f. distribution in the logit model may not always be correct. Logit assumes that the utility random variables U_{ij} are independent. The logit errors are uncorrelated, independent Weibull random variables distinguished by a skewed distribution and a non-zero mean. The probit assumptions allow for interdependence between the utility random variables and errors which have a normal distribution with a zero mean (Dhrymes, 1983). Because it allows the correlation of error terms and thus the utility levels, an assumption which seems more consistent with economic theory, probit is the preferred model in this research (Hill, 1997).

Probit Models

When repeated observations are unavailable, binary choice models may be estimated using maximum log likelihood methods. In a sample of T observations with binary choice variable y_i, explanatory variables vector x_i', and parameter vector $\boldsymbol{\beta}$, the log likelihood function is

$$L = \sum_{t=1}^{T} y_t \ln F(x_t'\beta) + \sum_{t=1}^{T} (1 - y_t) \ln[1 - F(x_t'\beta)], \tag{4.5}$$

where $F(\cdot)$ is the standard normal cumulative distribution function. This method will converge to the global maximum. The estimators are consistent, asymptotic efficient, and asymptotically normally distributed (Judge, *et al.*, 1988).

The likelihood ratio procedure can test the overall significance of the model under the null hypothesis:

$$H_0\colon \beta_2 = \beta_3 = \ldots = \beta_k = 0 \qquad (4.6)$$
$$H_1\colon \text{Not true.}$$

If n is the number of positive responses observed in the T observations, the maximum value of the restricted function, the log-likelihood function under the null hypothesis H_0 is

$$L(0) = n \ln (n/T) + (T-n)\ln ((T - n)/T). \qquad (4.7)$$

The likelihood ratio test is derived by computing the difference between L(0) and $L(\beta)$, calculated at the maximum likelihood estimates

$$\lambda = 2[\, L(0) - L(\beta)\,] \qquad (4.8)$$

which has a $\chi^2_{(k-1)}$ distribution (Judge, *et al.*, 1985). A likelihood ratio test statistic larger than the appropriate $\chi^2_{(k-1)}$ value leads to the rejection of the null hypothesis that all of the parameter estimates except the intercept are not significantly greater than zero.

Interpretation of Probit Results

Parameter estimates derived from probit models can be used to determine the direction and significance of the influence of the independent variable on the binary choice. These coefficients show the effect of a change in independent variable on the observed probit $F^{-1}(P_i)$ but lack any economic interpretation. The changes in probability are the partial derivatives of the probability function at the sample mean for each independent variable:

$$\delta P_i/\delta x_{ij} = f(x_i'\beta)\cdot\beta_j, \qquad (4.9)$$

where $f(x_i'\beta)$ is the p.d.f. and β_j is the parameter estimate.

Goodness of Fit Measures

In ordinary least squares model, the R^2 statistic, the ratio of explained sum of squares over total sum of squares, is used as a measure of goodness of fit. Because qualitative choice models do not use OLS estimation, the conventional R^2 is inappropriate. Substitute measures of goodness of fit have been created, most of which employ the restricted log likelihood statistic L(0) and the maximum log likelihood statistic $L(\beta)$. Formulae for the measures of goodness of fit are included in Appendix B.

McFadden's R^2 or pseudo- R^2 is equal to one minus the ratio of $L(\beta)$ over L(0). This measure is equal to zero when $L(\beta)$ equals L(0) or $\beta_i = 0$ for $i>1$. It equals one when the model is a perfect fit (Judge, *et al.*, 1988). The Adjusted McFadden R^2, R^2_{MFA}, weighs the $L(\beta)/L(0)$ ratio by a ratio derived from the sample size and number of parameters. Although these lie within the [0,1] interval they can not be used to explain variation as they involve all the characteristics of the distribution (Latilla, 1993).

Two additional goodness of fit measures for qualitative choice models are calculated by using the likelihood ratio statistic, λ, and sample size, N. Aldrich and Nelson's R^2, R^2_{AN}, is the ratio of λ over the sum of λ and sample size N. For a given sample size, this measure approaches one when the difference between $L(\beta)$ and L(0) is large, indicating a better model fit (Aldrich and Nelson, 1984). Veall and Zimmermann used a correction factor to place an upper bound on Aldrich and Nelson's measure (Windmeijer, 1995).

Collinearity Diagnostics

Collinearity results from a linear relationship between or among independent variables in the econometric model. This problem arises from the nonexperimental nature of the data commonly collected for analysis in the social sciences. Among other consequences, it may make difficult the precise estimation of the collinear variables. Estimates of parameters may appear insignificantly different from zero, leading to the exclusion of the parameters because of inadequacies in the data. Estimators may be sensitive to the inclusion or exclusion of observations or seemingly insignificant variables. The presence of collinearity may not compromise or limit the ability to make forecasts from the data sample estimates if the collinear relationships among variables in the sample are also collinear outside the sample (Judge, *et al.*, 1988).

When a model and a data sample have been identified, a number of diagnostic procedures can be used to detect the presence and source of collinearity. Examining the correlation matrix, $R = (X'X)$, can detect pair-wise collinearity between the variables in the data sample. Although there is no set standard, a correlation coefficient greater than 0.8 or 0.9 indicates a serious problem with collinearity. This method does not indicate more complex patterns of collinearity (Judge, *et al.*, 1988; Belsley, Kuh, and Welsch, 1980).

Because collinearity may exist among more than two variables, more comprehensive diagnoses were enacted. Examining the eigenvalues or eigenvectors of the correlation matrix R can also be used to detect collinearity. Small eigenvalues indicate problems with collinearity. Problematic of this diagnostic approach is the lack of an accepted standard for how small an eigenvalue indicates collinearity problems (Belsley, Kuh, and Welsch, 1988).

The condition index defines a standard for small eigenvalues by measuring the relative difference between the maximum eigenvalue μ_{max} and the kth eigenvalue μ_k. The kth condition index, η_k, is defined as

$$\eta_k = \mu_{max}/\mu_k. \tag{4.10}$$

An eigenvalue that is small relative to the yardstick μ_{max} indicates a large degree of collinearity. The largest condition index is also the index of the matrix. Although there is no set standard for how large a condition index indicates potential problems with collinearity, rules of thumb have come into use. Weak dependencies exist when condition indices range from 5 to 10. Moderate to strong relations are associated with condition indices of 30 to 100 (Belsley, Kuh, and Welsch, 1980).

The variance inflation factors (vif_i) are identified as the diagonal elements, r^{ii}, of the inverse of the correlation matrix, $R^{-1} = (X'X)^{-1}$. The diagnostic statistic of the variance inflation factor is derived from the following relationship:

$$vif_i = 1/(1 - R_i^2), \tag{4.11}$$

where R_i^2 is the multiple correlation coefficient of the variable x_i regressed on the other independent variables, x_j, $j \neq I$ (Belsley, Kuh, and Welsch, 1980). A large v.i.f. indicates that variable is not orthogonal to the others so may present a problem with collinearity. Values greater than 5.0 indicate a severe problem with collinearity (Judge, *et al.*, 1988).

Heteroskedasticity Diagnostics

Heteroskedasticity is a violation of the assumption of constant variance which may result in a biased estimator and misleading inferences. Multiplicative heteroskedasticity exists when the error variance is related to one of the explanatory variables:

$$E(e_t^2) = \sigma_t^2 = \exp(z_t'\alpha) = \exp(\alpha_1)\exp(z_t^{*\prime}\alpha^*) = \sigma^2\exp(z_t^{*\prime}\alpha^*). \qquad (4.12)$$

A test for multiplicative heteroskedasticity can be conducted by testing the above equation (4.12) as an alternative to the null of constant variance. Testing the following null and alternative hypotheses:

$$H_0: \alpha^* = 0 \qquad (4.13)$$
$$H_1: \alpha^* \neq 0$$

is equivalent to this procedure.

Economic Model

The probit model estimates willingness to pay as a function of economic, attitudinal, and socioeconomic variables. The probit model is expressed as:

WTPAY = F(HUNTSKIL, OUTSKIL, IMPDEV, BIOKNOW, SPECKNOW, WTPA, NEPAA, NEPFR, HIAGE, OTHERST, COLLEGE, MINOR, LGINCO, ϵ) (4.14)

where:

WTPAY	=	1 if the respondent answered "yes" to the willingness to pay for biodiversity habitat conservation in the Tensas River basin question; 0 otherwise
HUNTSKIL (+/-)	=	Likert scale indicator of respondent's self-reported hunting skills from "Beginner = 1" to "Expert = 4"

OUTSKIL	(+)	=	Likert scale indicator of respondent's self-reported skills at nonmotorized, nonconsumptive outdoor recreational activities from "Beginner = 1" to "Expert = 4"
IMPDEV	(+)	=	Likert scale indicator of the respondent's belief regarding the importance of the as an environmental issue "The rate at which land is being developed and places in nature are being lost"; from "Not Important at All" to "Very Important"
BIOKNOW	(+)	=	1 if respondent has heard of the term "biodiversity"; 0 otherwise
SPECKNOW	(+)	=	1 if the respondent correctly identified the decrease in the number of plant and animal species worldwide; 0 otherwise
WTPA	(-)	=	Randomly assigned amount on the respondent's questionnaire; WTPA = $1, $5, $10, $25, $50, $100, $150
NEPFR	(+)	=	Summary score of three items constituting the New Ecological Paradigm factor, Fragility of the Balance of Nature, Range = 3 to 15;
NEPAA	(+)	=	Summary score of three items constituting the New Ecological Paradigm factor, Anti-anthropocentricism, Range = 3 to 15;
HIAGE	(+/-)	=	Respondent age parameter; 1 if respondent is older than 66 years; 0 otherwise
OTHERST	(-)	=	Respondent residence parameter; 1 if respondent lived in Arkansas or Mississippi; 0 otherwise
COLLEGE	(+)	=	Respondent education parameter; 1 if respondent completed college or higher level of formal education;
MINOR	(+/-)	=	Number of persons less than 18 years old in the respondent's household
LGINCO	(+)	=	Respondent's income; Logarithm of the midpoints of seven ranges of income: Midpoints = $7,500; $20,000; $30,000; $40,000; $67,500, $87,500; $112,500
ϵ		=	Error term.

Two variables were included to estimate the effect of respondent's outdoor recreational preferences on passive use values for biodiversity habitat. A positive sign was predicted for OUTSKIL. Respondents who describe themselves as highly skilled at nonmechanized, nonconsumptive recreational activities, by virtue of their experience with natural settings, may have higher passive use values for natural habitat. Competing hypotheses were offered for HUNTSKIL. Participants may hold larger passive use values due to personal experience with natural areas. Conversely, their preferences for natural habitat may be primarily motivated by consumptive use which may diminish passive use values.

Three variables were included to estimate the influence of knowledge of and concern for environmental issues related to biodiversity. A positive sign was predicted for IMPDEV which measures concern for the loss of natural areas, the leading cause of species diversity decline locally and globally. BIOKNOW similarly was hypothesized to have a positive sign. A second parameter designed to measure knowledge of biodiversity issues was included to capture the effect of those who are not familiar with the technical term, biodiversity, but are aware of the status of species diversity. A positive sign was hypothesized for SPECKNOW, the correct identification of the decline in numbers of plant and animal species.

A negative sign was hypothesized for WTPA, the amount randomly assigned to each respondent. Respondents are less likely to respond positively to larger amounts presented in the dichotomous choice willingness to pay question.

This research hypothesized that a high NEP score, indicating a more ecological attitude, is positively related to willingness to pay. The five separate domains within the NEP, however, may provide more information regarding willingness to pay. The value of biodiversity preservation may be correlated more strongly with some domains than with others. Because of collinearity, NEP scores for all five domains could not be included simultaneously but two of the basic domains could be included in this model. The condition index η of a simple diagnostic model including all five NEP domains was 32.71 for the nonuser sample and 43.37 for the user sample, which indicated the presence of moderate to serious levels of collinearity. The New Environmental Paradigm, from which the New Ecological Paradigm was developed, identified two main domains: perceptions of the fragility of the balance of nature and anti-anthropocentric beliefs. The three additional domains within the NEP were refinements or expansions of these two (Dunlap, *et al.*, 1992). This research includes two variables representing these domains, NEPFR and NEPAA. Both domains are hypothesized to be positively related to willingness to pay.

The dummy variable defining age, HIAGE, was created to reduce collinearity among the continuous variable for age and the other variables in the model. HIAGE is defined as one for any respondent sixty-six years or older, an age one standard error greater than the mean for age in the general population sample. Competing hypotheses exist for this variable. Older respondents may value preserving habitat for biodiversity more highly due to an increase in bequest values developed at later stages in life. On the other hand, older residents who have demonstrated less concern with the environment may value biodiversity less than younger individuals.

OTHERST is a dummy variable designating residence in one of the two states other than Louisiana in the survey sample, Arkansas and Mississippi. Although passive use values are not limited by political boundaries, it is hypothesized that individuals may place less value on environmental assets outside than on those inside their resident state. A negative sign is hypothesized for this variable.

COLLEGE is a dummy variable identifying individuals who have finished college or higher levels of formal education. Because education is positively correlated with value for environmental amenities, a positive sign is hypothesized for this variable.

Competing hypotheses exist for the variable MINOR. Households with larger numbers of inhabitants under the age of eighteen may possess larger bequest values, a component of passive use values. Contrarily, households with larger numbers of minors may encounter budget constraints imposed by larger families which reduce passive use values.

Because biodiversity is assumed to be a normal good, willingness to pay for habitat preservation for biological diversity is hypothesized to be positively correlated with income. A continuous variable, INCO, was created from the midpoints of the seven income ranges defined in the questionnaire. Income has been a source of heteroskedasticity in past studies of expenditures. A log-likelihood test for heteroskedasticity conducted by LIMDEP 7.0 indicated that inclusion of the income parameter in this specification introduced multiplicative heteroskedasticity into the model. At low levels of income, expenditures may be explained largely by income while, at higher incomes, a number of other factors, such as tastes and preferences, may also affect value for environmental amenities (Judge, *et al.*, 1988).

To reduce problems with heteroskedasticity associated with INCO, a new variable, LGINCO, was created from taking the logarithm of INCO. This monotonic transformation of the original variable maintains the sign of the income independent variable but changes the interpretation of the parameter estimate. By compacting range of the independent variable, the logarithmic variable removes the problem of heteroskedasticity as tested by the log-likelihood test for multiplicative heteroskedasticity in LIMDEP 7.0 (White, 1995).

Probit Model Results for the Nonuser Model

As previously defined, the nonuser group consists of 909 observations from the general population sample who did not report visiting the Big Lake Wildlife Management Area or the Tensas River National Wildlife Refuge. Following Arrow, *et al.*, (1993) and Reaves, *et al.*, (forthcoming), protest "no's" were excluded from the analysis. Protest "no's" were identified as marking a response to question Q-22 which indicated that the respondent answered negatively to the willingness to pay due to a rejection of the payment format or an objection to paying for the preservation of wildlife habitat. This reduced the sample size by 246 to 663. Due to incomplete questionnaires, an additional 131 observations were omitted, resulting in 532 useable observations. Descriptive statistics for continuous variables and dummy variables for the nonuser sample are included in tables 4.1 and 4.2, respectively.

To detect the presence of heteroskedasticity, a test for multiplicative heteroskedasticity was conducted. This test is structured similarly to the test for model

Table 4.1 Descriptive Statistics for Continuous Variables from the Nonuser Sample

Variable	Sample Mean	Standard Deviation
HUNTSKIL	0.761	1.261
OUTSKIL	0.830	1.074
IMPDEV	3.58	0.644
WTPA	44.05	51.311
NEPAA	10.206	2.584
NEPFR	11.312	2.12
AGE	51.031	16.191
MINOR	0.619	1.008
INCO	44,192.80	30,871.59
LGINCO	10.415	0.819
N = 663		

Table 4.2 Frequency Tables for Dummy Variables from Nonuser Sample

	Value = 0		Value = 1	
Dummy Variable	Frequency	Percent	Frequency	Percent
BIOKNOW	441	66.5	222	33.5
SPECKNOW	191	28.8	472	77.2
HIAGE	521	78.6	142	21.4
COLLEGE	420	63.3	243	36.7
WTPAY	439	66.2	224	33.8
N = 663				

significance in equation (4.8). In this test, the restricted model assumes the error term is a function of all the independent variables identified. Using this model, LIMDEP (Greene, 1995) generates a maximum log-likelihood ratio, L(R), which is tested against the maximum log-likelihood ratio from the unrestricted model, L(β). The likelihood ratio statistic for homoskedasticity has a χ^2 distribution with 13 degrees of freedom:

$$\lambda_H = -2(L(\beta) - L(R)) = -2(-270.775 - (-261.1447)) = 19.2606. \qquad (4.15)$$

The 95 percent critical value is 22.3620. Under the LGINCO specification, the hypothesis of homoskedasticity was not rejected.

Because the examination of the correlation matrix, R, did not reveal any correlation coefficients greater than the benchmark 0.8 or 0.9. there was no evidence of pair-wise collinearity between any of the independent variables in the nonuser sample. More importantly, none of the variance inflation factors for any of the variables exceeded 1.622, far below the vif rule of thumb standard of 5 which indicates the presence of collinearity.

The examination of the eigenvalues did show relatively small values, $\mu_{14} = 0.00194$, which could indicate potential presence of collinearity. The condition index η equals 65.58, greater than the standard condition index $\eta = 30$ which is said to indicate moderate to strong collinearity.

The source of collinearity is connected to the variable, LGINCO. The condition index for this variable greatly increases from that of the previous variable ($\eta_{13} = 22.09$). In a previous model, when the income parameter was defined as INCO, the condition index was approximately 24. The sizeable increase in the condition index across models and from one variable to another within the same model indicates that the specification of LGINCO is the likely cause of the increase.

The presence of collinearity is a data problem which does not necessarily have serious implications for the model estimates themselves. An alternative specification of the model, which was heteroskedastic but not collinear, provided estimates which did not differ significantly from those of the current specification of the model which is homoskedastic but collinear. In this model, the effects of collinearity do not appear compromising.

The residual, e_i, was calculated as the difference between the observed dependent variable, $WTPAY_i$ and the predicted probability, F_i. Although a plot of the residuals can be difficult to interpret (Pagan and Vella, 1989), a graphical analysis of the error term was performed to examine its distribution. The shape of residual distribution followed the expected pattern across ranges of explanatory variables, including WTPA and LGINCO, and did not suggest heteroskedasticity, supporting the conclusion derived from the LIMDEP results. As estimated by SAS 6.11, the standard deviation of the error term was 0.4132. The mean, $\mu_e = -0.000615$, was not significantly different from zero. Using SAS 6.11, a histogram of the residaul demonstrated a dispersion similar to that of a normal distribution. The largest number of frequencies occurred within the range -1.5 to -0.5 with a midpoint of -1.0. The distribution is slightly skewed with 54.3 percent of the errors occurring to the left of the sample mean.

Probit Parameter Estimates

Using the log likelihood procedure to estimate the probit model in equation (4.14), LIMDEP 7.0 produced the parameter estimates in table 4.3. The parameter estimates provide the direction and significance of the change in the probability of a "yes" response. The marginal effects provide a measure of the magnitude of the change in probability following a change in the independent variable.

The insignificance of HUNTSKIL and OUTSKIL do not support the hypothesis that individual preferences for outdoor recreation affect passive use values for habitat preservation. This would suggest that individuals may value biodiversity preservation regardless of outdoor recreational activity.

The positive and significant sign on IMPDEV supports the hypothesis that biodiversity preservation is more highly valued by individuals who are more concerned about the rate at which places in nature are being developed, the principal impetus behind the biodiversity decline. The parameter for BIOKNOW, while significant at the 90 percent significance level, is not significant at the 95 percent significance level preferred for this analysis. By this criterion, knowledge of the technical term, "biodiversity", is not significantly related to the value one places on the preservation of biological diversity. The positive and significant sign of SPECKNOW, however, supports the hypothesis that persons who are aware of the decline in species number are willing to pay more for biodiversity preservation than those who do not.

The negative and significant sign on WTPA supports the hypothesis that the probability of a yes declines as the randomly assigned amount on the questionnaire

Table 4.3 Probit Maximum Likelihood Estimates for the Nonuser Sample

Variable	Parameter Coefficient	Z-value	Marginal Effects	Z-value	Variable Mean
CONSTANT	-5.750	-5.124*	-2.207	-5.209	
HUNTSKIL	0.0139	0.272	0.0049	0.272	0.8252
OUTSKIL	0.0445	0.722	0.0157	0.722	0.8778
IMPDEV	0.2388	1.971*	0.0839	1.974	3.566
BIOKNOW	0.2400	1.773**	0.0843	1.769	0.3553
SPECKNOW	0.3685	2.205*	0.1295	2.214	0.7406
WTPA	-0.0114	-7.577*	-0.0039	-7.861	43.77
NEPFR	0.0914	2.475*	0.03213	2.469	11.31
NEPAA	0.0241	0.828	0.00848	0.829	10.21
HIAGE	0.0140	0.076	0.00493	0.076	0.1748
OTHERST	-0.0761	-0.362	-0.2674	-0.362	0.1053
COLLEGE	0.3839	2.647*	0.13493	2.653	0.3872
MINOR	-0.1965	-2.959*	-0.0696	-2.964	0.6692
LGINCO	0.3037	3.277*	0.10672	3.292	10.48

N = 532

Log Likelihood Ratio = -270.7750
Restricted Log Likelihood Ratio = -346.1426 with 13 degrees of freedom
Likelihood Test = 150.7352
Percentage of Right Predictions = 75.94 percent

R^2_{AN}=0.221 R^2_{VZ}=0.390 R^2_{MF}=0.218 R^2_{MFA}=0.198

* Significant at 95 percent confidence level (critical z-statistic = 1.96)	** Significant at 90 percent confidence level (critical t-statistic = 1.645)

increases. This result supports the claim of a downward sloping demand curve for biodiversity habitat preservation and is important in estimating mean willingness to pay. The sample mean for WTPA, μ, is \$44.05 less than the average questionnaire value for WTPA, mean(WTPA) of \$48.71. Because a sample mean significantly different than the questionnaire mean could be a source of downward bias, a null hypothesis of sample mean equality to questionnaire mean is tested against the alternative hypothesis:

$$H_0: \mu = \text{mean(WTPA)} \qquad (4.16)$$
$$H_1: \mu \neq \text{mean(WTPA)}.$$

The null hypothesis may be tested with a t-statistic:

$$t_{(0.05,\ 662)} = \frac{\mu - \text{mean(WTPA)}}{\text{s.e.(WTPA)}} = \frac{44.05 - 48.71}{51.311} = -0.091. \qquad (4.16a)$$

Because the test t-statistic is less than the critical t-value of 1.96, the null hypothesis that the sample mean is not significantly different from the questionnaire mean is not rejected. Because there is not a significant difference between the sample and questionnaire mean, there does not appear to be any downward bias resulting from a low sample mean WTPA.

The separation of the two separate domains within the NEP supports the hypothesis that willingness to pay for biodiversity preservation is more strongly related to one domain than another. The significance of NEPFR supports the hypothesis that the value of biodiversity is positively related to the degree of one's pro-ecological view of the fragility of the balance of nature. The insignificance of NEPAA does not support the hypothesis that an anti-anthropomorphic attitude is related to one's value of biodiversity. The distinction demonstrates the value of measuring the factors of the NEP separately.

The insignificance of HIAGE does not support the hypothesis that the value of biodiversity preservation differs among older individuals. Similarly, the insignificance of OTHERST does not support the hypothesis that the value of biodiversity preservation declines among individuals who live in states outside the one which contains the habitat in question. The relatively low response rate among residents of other states, however, may suggest that those individuals do not value the resource as highly as residents of Louisiana as they may have been less willing to respond to a survey from a source outside their resident state.

The positive significance of COLLEGE supports the hypothesis that individuals with higher levels of formal education value biodiversity habitat more highly than those with less education. The negative and significant sign on MINOR supports the hypothesis that households with larger numbers of minor aged occupants value habitat preservation less than those with smaller numbers of young residents, perhaps from a decrease in discretionary income.

The positive and significant sign on LGINCO supports the hypothesis that biodiversity preservation is a normal good. The marginal effects presented in table 4.3 are given for a unit change in the log of income, not income itself. The change in probability for income for a unit change in income is represented by (Ramanathan, 1992):

$$\delta P_i/\delta INCO_{ij} = (\delta P_i/\delta LGINCO_{ij})(\delta LGINCO_{ij}/\delta INCO_{ij}) = f(x_i'\beta)\cdot\beta_j / INCO_{ij}. \quad (4.17)$$

The welfare measure, mean willingness to pay, is estimated by calculating the area under the probability function. Integrating this function across questionnaire amount, WTPA, by using SAS 6.11, the mean willingness to pay for the nonuser sample is estimated as \$36.84.

Probit Model Results for the User Model

The user sample group was defined as the 638 respondents from the Tensas lottery sample plus the 33 respondents from the general population sample who visited Big Lake Wildlife Management area or the Tensas River National Wildlife Refuge in 1996. Of these 671 observations, 145 protest "no's" were dropped from analysis for a sample of 526. Due to incomplete questionnaires, 55 observations were dropped, resulting in a sample size of 471. Descriptive statistics for the continuous and the dummy variables for the user sample are presented in table 4.4 and 4.5, respectively.

The maximum likelihood estimates for the probit model for the user sample in equation (4.14) are presented in table 4.6. In contrast to the nonuser sample, the parameter estimate for HUNTSKIL is positive and significant. This result supports the hypothesis that persons of higher skill levels and presumably more experience with hunting place a larger value on biodiversity preservation. The insignificance of OUTSKIL does not support the hypothesis that participants in non-motorized non-consumptive recreational activities are more likely to be willing to pay for biodiversity preservation.

SPECKNOW is significant at the 95 percent level. Except for IMPDEV, none of the attitudinal measures is significant. The significance of this sign could be attributed to users' concerns for preserving habitat for recreational purposes rather than for passive use preservation values. While the negative and significant sign on WTPA does support the hypothesis of a downward sloping demand curve. The insignificance of LGINCO does not

Table 4.4 Descriptive Statistics for the Continuous Variables from the User Sample

Variable	Sample Mean	Standard Deviation
HUNTSKIL	2.902	0.842
OUTSKIL	1.437	1.203
IMPDEV	3.803	0.469
WTPA	44.106	49.76
NEPAA	10.61	2.600
NEPFR	11.71	1.917
AGE	39.82	12.10
MINOR	1.092	1.167
INCO	44,192.80	23,271.58
LGINCO	10.530	0.618
N = 512		

Table 4.5 Frequency Tables for Dummy Variables from User Sample

Dummy Variable	Value = 0		Value = 1	
	Frequency	Percent	Frequency	Percent
BIOKNOW	316	60.1	210	39.9
SPECKNOW	172	32.7	354	67.3
HIAGE	508	96.6	18	3.4
COLLEGE	417	79.3	109	20.7
WTPAY	241	45.8	285	54.2
N = 526				

Table 4.6 Probit Maximum Likelihood Estimates for the User Sample

Variable	Parameter Coefficient	Z-value	Marginal Effects	Z-value	Variable Mean
CONSTANT	-4.0418	-2.739*	-1.6077	-2.736	
HUNTSKIL	0.3090	3.537*	0.1223	3.536	2.915
OUTSKIL	0.0499	0.861	0.0198	0.862	1.469
IMPDEV	0.4866	2.824*	0.1934	2.823	3.794
BIOKNOW	0.1089	0.775	0.0433	0.775	0.4161
SPECKNOW	0.2944	1.983*	0.1170	1.982	0.6752
WTPA	-0.0161	-10.693*	-0.0064	-10.62	45.19
NEPFR	0.0378	0.910	0.0151	0.910	11.71
NEPAA	0.0288	0.944	0.0114	0.944	10.61
HIAGE	-0.0373	-0.769	-0.1482	-0.769	0.0255
OTHERST	-0.2160	-0.293	-0.0859	-0.293	0.0085
COLLEGE	0.01672	0.092	0.0066	0.092	0.229
MINOR	-0.0483	-0.783	-0.0192	-0.783	1.100
LGINCO	0.1046	0.863	0.0416	0.863	10.54

N = 471

Log Likelihood Ratio = -236.1342
Restricted Log Likelihood Ratio = -324.6856 with 13 degrees of freedom
Likelihood Test = 177.028
Percentage of Right Predictions = 77.92 percent

R^2_{AN}= 0.273 R^2_{VZ}= 0.471 R^2_{MF}= 0.272 R^2_{MFA}= 0.293

* Significant at 95 percent confidence level (critical z-statistic = 1.96)	** Significant at 90 percent confidence level (critical t-statistic = 1.645)

support the hypothesis that habitat preservation is a normal good among respondents from this sample. This model provides an estimate of $30.57 for mean willingness to pay for passive use values of biodiversity preservation. Although the goodness of fit measures and prediction rate for the user sample compares favorably with those of the nonuser sample, the model specification for the user sample does not appear to have the same explanatory power. Explanations for the model misspecification may result from econometric, theoretical, or conceptual origins.

For the user group, the log-likelihood statistic, λ_H, of 0.12 does not indicate the rejection of the null hypothesis of homoskedasticity. The small eigenvalue (0.00130) indicates the potential presence of collinearity. The condition index of 83.195 also indicates the presence of serious levels of collinearity, which may result from the inclusion of irrelevant variables.

A graphical analysis of the residual, $e_i = WTPAY_i - F_i$, was performed in SAS 6.11. The standard distribution of the error was 0.4047 and the mean was -0.000996, which is not significantly different from zero. In a histogram of the residuals, the largest number of frequencies occurred within the range 0.15 to 0.2 with a mean of 0.2. Because only 45 percent of the observed errors occur to the left of the sample error mean, the distribution is skewed to the right. The dispersion of the residual also demonstrates kurtosis, with some fatness in the negative tail. The dispersion of the residal was not conclusively similar to that of a normal distribution, which suggests model misspecification.

The misspecification of the model may also result from conceptual differences between the sample groups. According to Silberman, Gerlowski, and Williams (1992), resource users may not be able to provide a measure of passive use value which does not contain some spill over from their use values. If the value provided by the respondents contains elements of use value, the relevant variables may be those related to recreational use values of the habitat. For the value of hunting recreation, measures of ecological attitude and socioeconomic variables such as age, education, and household size may not be relevant variables. Furthermore, the lack of variation in willingness to pay with respect to income may be related to the size of the questionnaire amounts. To many respondents, the largest questionnaire amount, \$150, may not be perceived as a significant price for hunting.

Another model for the user sample was hypothesized. This model treats many of the insignificant variables as irrelevant and drops them from the econometric analysis. It is hypothesized that users who recreated within the Tensas River basin within the last year are willing to pay more than those who have not visited the area recently. This model also includes a variable, FAMIL, identifying those in the user sample who visited the Tensas River basin parks in 1996:

WTPAY = F(HUNTSKIL, FAMIL, IMPDEV, SPECKNOW, WTPA, INCO, ϵ) (4.18)

where:

WTPAY		=	1 if the respondent answered "yes" to the willingness to pay question; 0 otherwise
HUNTSKIL	(+/-)	=	Likert scale indicator of respondent's self-reported hunting skills from "Beginner = 1" to "Expert = 4"
FAMIL	(+)	=	1 if the respondent reported visiting the Big Lake Wildlife Management area or the Tensas River National Wildlife Refuge in 1996; 0 otherwise

IMPDEV	(+)	=	Likert scale indicator of the respondent's belief regarding the importance of the as an environmental issue "The rate at which land is being developed and places in nature are being lost"; from "Not Important at All" to "Very Important"
SPECKNOW	(+)	=	1 if the respondent correctly identified the decrease in the number of plant and animal species worldwide; 0 otherwise
WTPA	(-)	=	Randomly assigned amount on the respondent's questionnaire; WTPA = \$1, \$5, \$10, \$25, \$50, \$100, \$150
INCO	(+)	=	Respondent's income; Midpoints = \$7,500; \$20,000; \$30,000; \$40,000; \$67,500, \$87,500; \$112,500
ϵ		=	Error term.

The probit maximum likelihood estimates for the model in equation (4.17) and marginal effects are presented in table 4.7. The likelihood ratio statistic, λ, is 183.1528 which leads to the rejection of the hypothesis that all the explanatory parameters except the intercept are zero. The measures of goodness of fit in this modified model are comparable to those from the previous model. The rate of correct prediction is also similar to that of the previous model for the user sample.

Collinearity diagnostics do not indicate the presence of a serious degree of collinearity. No correlation coefficients are greater than the 0.8 or 0.9 standard which indicates the presence of pairwise collinearity. The maximum variance inflation factor is 1.04 and does not indicate collinearity. The condition index for this model specification is 29.0 which falls below level of the 30 which indicates the presence of moderate to serious degrees of collinearity. The likelihood ratio statistic, λ_H, estimated by LIMDEP 7.0 is 3.8811, which does not lead to the rejection of the null hypothesis of multiplicative

Table 4.7 Maximum Likelihood Estimates for the Modified Model of the User Sample

Variable	Parameter Coefficient	Z-value	Marginal Effects	Z-value	Variable Mean
CONSTANT	-2.8111	-4.336*	-1.1179	-2.736	
HUNTSKIL	0.2814	3.447*	0.1119	3.447	2.90
FAMIL	0.2532	1.529	0.1007	1.529	0.8045
IMPDEV	0.5690	3.694*	0.2263	3.691	3.800
SPECKNOW	0.2933	2.067*	0.1166	2.066	0.6782
WTPA	-0.0159	-10.780*	-0.0063	-10.693	44.86
INCO	0.000005	1.722**	0.0416	0.863	10.54

N = 491

Log Likelihood Ratio = -247.0451
Restricted Log Likelihood Ratio = -338.6215 with 6 degrees of freedom
Likelihood Test = 183.1528
Percentage of Right Predictions = 76.58 percent

R^2_{AN}= 0.272 R^2_{VZ}= 0.468 R^2_{MF}= 0.270 R^2_{MFA}= 0.260

* Significant at 95 percent confidence level (critical z-statistic = 1.96)

** Significant at 90 percent confidence level (critical z-statistic = 1.645) homoskedasticity. Because of the absence of multiplicative heteroskedasticity in conjunction with the use of the INCO term, this model does not include the LGINCO specification used in previous models. The use of the variable INCO reduced the degree of collinearity in the data sample. With the INCO variable, the change in the probability of a positive response can be interpreted directly from the marginal effects.

In the modified model (4.17), the positive and significant sign on HUNTSKIL supports the hypothesis that willingness to pay for habitat preservation is larger among more highly skilled hunters. The insignificant parameter estimate for the variable FAMIL does not support the hypothesis that willingness to pay for the preservation of a particular site is larger among those who have visited the location of the amenity within the recent past.

The positive and significant sign on SPECKNOW indicates that individuals who are aware of the decline in the number of plant and animal species place a higher value on the preservation of habitat. The sign of IMPDEV suggests that persons who consider the rate of development of natural areas to be an important issue are willing to pay more for habitat preservation than individuals who are less concerned with this topic.

The negative and significant sign on WTPA supports the hypothesis that the probability of a positive response to the dichotomous choice willingness to pay question declines as the randomly assigned amount on the questionnaire increases. The positive sign on INCO is significant at the 90 percent confidence level but not at the 95 percent confidence level preferred in this analysis.

Residual analysis was performed in SAS 6.11. With a standard error of 0.4061, the mean, μ_e = -0.00179, is not significantly different from zero. The largest number of frequencies, 95, 19.4 percent, occurs in the range 0.1 to 0.2 with a mean of 0.15. With only 45.8 percent of the observations occurring to the left of the sample mean, the distribution is skewed to the right. Evidence suggests the presence of kurtosis with a large number of observations in the left tail. Because the distribution of the error term does not conclusively approach the normal distribution, there is further evidence of model misspecification.

To test for misspecifcation of the modified model (4.18) against the original specification, equation (4.14), a diagnostic test developed by Davidson and MacKinnon (1984) was performed. This test specifies the null hypothesis that willingess to pay is a function of the set of variables included in equation 4.18 against the alternative hypothesis that willingness to pay is a function of the variable in equation 4.14:

H_0: WTPAY = F(HUNTSKIL, FAMIL, IMPDEV, SPECKNOW, WTPA, INCO, ϵ) (4.19)

H_1: WTPAY = F(HUNTSKIL, OUTSKIL, IMPDEV, BIOKNOW, SPECKNOW, WTPA, NEPFR, NEPAA, HIAGE, OTHERST, COLLEGE, MINOR, LGINCO, ϵ).

This hypothesis is tested by regressing a function of the residual of the model presented in the null hypothesis against the elements of the information matrix and a function of the difference between the cumulative density functions from the separate models. The parameter estimate corresponding to the latter explanatory variable can be used in a t-test to test the null hypothesis (Greene, 1995). For this sample, at the 95 percent hypothesis level, the t-statistic, $t = 1.976$, supports the rejection of the null hypothesis in favor of the alternative that the model presented in equation 4.14 is the preferred model structure.

The differences in model specifications between the nonuser group and the user groups suggest that individuals in the two samples value the preservation of habitat within the Tensas River basin differently. The insignificance of attitude variables, such as the NEP or its domains, indicate that the value of preserving habitat does not vary with the environmental or ecological attitude of members of the user group. This might suggest the respondents replying to the valuation question did not perceive the benefit as primarily environmental but rather recreational, e.g., the improvement of hunting area. The mean willingness to pay estimate from the modified model of the user group is $7.29. This estimate may be inaccurate as a result of model misspecification. A more dependable estimate of the benefit of habitat enlargement may elicit use values from the user groups and passive use values from the general population group. Because the estimation of the use value of habitat preservation in the Tensas River basin requires data not available in this sample, this analysis will not estimate use values for the user sample. Following Silberman, Gerlowski, and Gowan, (1992) and Mitchell and Carson (1989), this research concludes that the user group should be excluded from the estimation of passive use values.

Multinomial Logit Analysis

Dichotomous choice willingness to pay has been evaluated using binary dependent variable models, such as logit and probit, because the valuation question was presented to the survey respondent as a choice between the acceptance or rejection of a randomly assigned amount of money. On the advice of the NOAA Blue Ribbon panel, the dichotomous choice question in this study was revised to include a "no choice" alternative (Arrow, *et al.*, 1993). This response alternative is usually presented to the respondent as "I am not certain" or "I do not know". In practice, the no choice alternative has been combined with the "no" alternative to form a "not yes" alternative which can be used against the "yes" response in binary dependent variable models (Randall, 1997).

This research investigates the hypothesis that distinguishing between the "no" and "no choice" alternatives can reveal information regarding the choice decision which may not be revealed by combining the two. This research uses a polychomotous choice model to examine the selection among the three alternatives.

Multinomial Logit

Multinomial qualitative choice dependent variable models are a generalization of the binary choice model which extends the choice decision to include multiple alternatives in a utility maximizing framework. The multinomial logit model, like the standard logit model, assumes that the disturbance terms e_{ij} are independently and identically distributed with Weibull density functions. The mutinomial probit model assumes the error terms e_{ij} are normally distributed. The multinomial probit model, because it allows the correlation of e_{ij}'s, may be preferred to multinomial logit on theoretical grounds (Judge, *et al.*, 1985). Difficulty in estimating and interpreting the results of multinomial probit models, however, lead many practicing researchers to use the computationally convenient alternative (Liao, 1994; Greene, 1995).

In the multinomial logit model, the probability of choosing alternative j by individual I is represented by:

$$P_{ij} = \frac{\exp(x_i'\beta)}{1 + \sum_{j=1}^{J} \exp(x_j'\beta)}. \tag{4.20}$$

Maximum likelihood estimation in the multinomial model is similar to that of the binary case. The likelihood function estimates all B = K(J-1) coefficients by the following:

$$L(WTPAY|X,\beta) = \prod_i \prod_j [\exp(x_i'\beta)/\sum_{j=1}^{J} \exp(x_j'\beta)]^{N_{ij}} \tag{4.21}$$

The maximum likelihood estimates are the values of B which maximize equation (4.18). These are found using the iterative algorithm method used in binary choice (Aldrich and Nelson, 1984).

The changes in probability or the marginal effects for alternative j resulting from a change in the ith variable are (Greene, 1995):

$$\partial P_j / \partial x_i = P_j(\beta_j - \Sigma_k P_k(\beta_k). \tag{4.22}$$

For multinomial logit models, inferences about the direction and magnitude of the marginal effects can not be made from the parameter estimates. Hypotheses are formulated only for the direction of the marginal effects on probabilities.

The selection of a decision alternative considered in the multinomial framework is hypothesized to be a function of the same factors presented in equation (4.14). No hypotheses have been formulated for the signs of the marginal effects in the model.

The likelihood ratio statistic, λ, is 205.8627 which leads to the rejection of the null hypothesis that all the parameter estimates except the intercept are zero. Parameter estimates for the maximum likelihood estimation of the multinomial logit model are presented in table 4.8. Marginal effects and z-statistics zero are shown in table 4.9.

Although outdoor recreational preferences, HUNTSKIL and OUTSKIL, do not significantly affect the probability of any of the three responses, the marginal effects of selected knowledge and attitudinal variables are significant. The respondent's rating of the importance of the issue of the rate of the development of places in nature (IMPDEV) is significantly related to the probability of a positive response at the ninety-five percent confidence level. A one unit increase in IMPDEV increases the probability of a "yes" by 9.16 percent.

Knowledge of the term "biodiversity" (BIOKNOW) reduces the probability of a "no" by 10.71 percent at the ninety-five percent confidence level. The knowledge of this term is significantly related to a positive response only at the 90 percent confidence level. At this level of confidence, the knowledge of the term "biodiversity" increases the probability of a positive response by 9.09 percent. Knowledge of the decline in the number of plant and animal species (SPECKNOW) is significantly related to the probability of a positive or "no response" answer but insignificantly related to a negative answer. Knowledge of the decline in animal and plant species increases the probability of a positive response by 13.1 percent and decreases the probability of an "I am not certain" response by 13.4 percent.

An increase in WTPA, the amount of the money solicited on the questionnaire, significantly reduces the probability of a positive response and increases the probability of a negative response. A one unit increase in WTPA lowers the probability of a positive

Table 4.8 Maximum Likelihood Estimation of the Parameters from the Multinomial Logit Model for the Nonuser Sample

Variable	Mean	"No" vs. "I am not certain." β	Z-Value	"Yes" vs. "I am not certain." β	Z-Value	"Yes" vs. "No" β	Z-Value
CONSTANT		9.050*	4.381	-5.229*	-2.415	2.336*	-6.111
HUNTSKIL	0.821	0.137	1.371	0.087	0.902	-0.049	-0.477
OUTSKIL	0.878	-0.061	-0.492	0.067	0.568	0.124	0.989
IMPDEV	3.563	-0.018	-0.088	0.415	0.568	0.433**	1.817
BIOKNOW	0.355	-0.038	-1.385	0.242	0.955	0.617*	2.177
SPECKNOW	0.740	0.380	1.359	0.790*	2.562	0.410	1.251
WTPA	43.69	0.011*	4.859	-0.014*	-4.633	-0.025*	-8.238
NEPFR	11.31	-0.153*	-2.141	0.085	1.221	0.238*	3.169
NEPAA	10.19	-0.144*	-2.496	-0.006	-0.104	0.139*	2.305
HIAGE	0.173	0.030	0.089	0.104	0.296	0.074	0.201
OTHERST	0.105	0.227	0.568	0.041	0.102	-0.186	-0.453
COLLEGE	0.388	0.283	0.257	0.645*	2.367	0.572**	1.92
MINOR	0.667	0.115	0.306	-0.310*	-2.476	-0.345*	-2.539
LGINCO	10.48	-0.636*	-3.651	0.234	1.320	0.870*	4.556

N = 526

Log Likelihood Ratio = -473.0668
Restricted Log Likelihood Ratio = -575.9981 with 26 degrees of freedom
Likelihood Test = 205.8627
Percentage of Right Predictions = 57.79 percent

R^2_{AN}= 0.28129 R^2_{VZ}= 0.4097 R^2_{MF}= 0.2704 R^2_{MFA} = 0.1342

* Significant at 95 percent confidence level (critical z-statistic = 1.96)

** Significant at 90 percent confidence level (critical t-statistic = 1.645)

Table 4.9 Maximum Likelihood Estimation of the Parameter Marginal Effects from the Multinomial Logit Model for the Nonuser Sample

Variable	"I am not certain."	Z-Value	"No"	Z-Value	"Yes"	Z-Value
HUNTSKIL	-0.0258	-1.325	0.0296	1.062	0.0048	0.255
OUTSKIL	-0.0005	-0.022	-0.0466	-0.825	0.0207	0.898
IMPDEV	-0.0450	-1.077	0.1071	-1.123	0.0916	1.999*
BIOKNOW	0.0161	0.317	-0.1071	-1.982*	0.0910	1.813
SPECKNOW	-0.1339	-2.288*	0.0020	0.033	0.1320	2.074*
WTPA	0.0002	0.481	0.0039	7.892*	-0.0041	-6.879*
NEPFR	0.0082	0.588	-0.0423	-2.988*	0.0342	2.501*
NEPAA	0.0175	1.566	-0.0311	-2.691*	0.0136	1.246
HIAGE	-0.0154	-0.227	-0.0040	-0.060	0.1940	0.284
OTHERST	-0.0311	-0.392	0.0455	0.591	-0.0144	-0.188
COLLEGE	-0.0816	-1.499	-0.0504	-0.889	0.1321	2.435*
MINOR	0.0310	1.346	0.03962	1.647**	-0.0707	-2.77*
LGINCO	0.0474	1.386	-0.1636	-4.639*	0.1162	3.288*

* Significant at 95 percent confidence level (critical z-statistic = 1.96)

** Significant at 90 percent confidence level (critical t-statistic = 1.645) response by 0.414 percent and raises the probability of a negative response by 0.389 percent. This relationship is consistent with a downward sloping demand curve for biodiversity habitat preservation.

The multinomial logit results reveal changes in probability in response to changes in the scores for the two NEP domains used in this analysis. A one unit increase in the score for the domain regarding the fragility of the balance of nature, NEPFR, increases the probability by a statistically significant 3.42 percent and decreases the probability of a negative response by a statistically significant 3.11 percent. An increase in the score of the NEP domain concerning anti-anthropomorphic ethical attitudes does not significantly affect the probability of a positive response but does significantly decrease the probability of a negative response by 1.3 percent.

Education is significantly related to the probability of a positive response. The probability of a "yes" response increased by 13.2 percent among respondents who attained a Bachelor's degree or higher. The negative sign on the household size variable, MINOR, indicates that a one unit increase in the number of minors in the house decreases the probability of a "yes" response by 7.07 percent at the ninety-five percent significance level. At the ninety percent confidence level, MINOR reduces the probability of a no by a statistically significant 3.97 percent. These results support the hypothesis that an increase in the number of children in the household reduces the willingness to pay for passive use values, perhaps as a result of restraints on discretionary income imposed by the expenses and responsibilities of raising a family.

The income parameter, LGINCO, is significantly related to the probability of a positive or negative answer but not the "no response" alternative. A one unit increase in the log of income reduces the probability of a negative response by 16.36 percent. The increase in the log of income increases the probability of a positive response by 11.62 percent. These results support the hypothesis that biodiversity habitat preservation is a normal good.

Of all the variables in the multinomial logit model, only knowledge of the decline in plant and animal species has significant marginal effects on the probability of a "no response" answer. The significance of the negative parameter for SPECKNOW indicates that knowledge of the status of species number reduces the inability to choose between a positive or negative response. The insignificance of the other variables indicates that the inability to do so does not vary significantly with any other environmental attitude or ethical attributes nor with age, family size, income, or educational attainment.

Conclusion

This chapter has reported the empirical analysis of the passive use values of biodiversity preservation in the Tensas River basin. After defining two separate samples for analysis, a user sample and a nonuser sample, it has concluded that the nonuser sample is appropriate for the estimation of passive use values. Users of the resource do not appear to give an estimate of passive use values which do not contain some elements of use value as well. This intermingling of user group respondent's use values and nonuse values suggests that models estimating passive use value alone may be misspecified. The estimation of consumer benefits for the user group associated with an increase in natural habitat requires data that is not available from this sample.

Binomial probit analysis of the nonuser groups reveals an estimated mean willingness to pay of $36.84 per household. The value of biodiversity habitat preservation in the Tensas River basin increases significantly among individuals who are relatively more concerned with the rate at which places in nature are being developed and individuals who are aware of the decline in the number of plant and animal species. The value of biodiversity habitat preservation increases among individuals who score high on the NEP index indicating a belief in the fragility of the balance of nature. An increase in the number of minor children in a household reduces the willingness to pay for biodiversity. An increase in educational attainment and income increase the value for biodiversity preservation.

In addition to the binomial probit analysis, this research has conducted a multinomial logit analysis of the decision alternatives in the willingness to pay elicitation question. The marginal effects of a positive response are positively related to knowledge of the decline in species, concern regarding the development of natural areas, beliefs regarding the fragility of nature, education, and income. The probability of a positive response declines with an increase in household size.

The marginal effects of the probability of a negative response are positively related to the number of minor children in the household. The probability of a negative response is negatively related to the knowledge of the term "biodiversity", attitudes concerning the fragility of nature and anti-anthropomorphism, and income. The marginal effects of the "no response" alternative are negatively related to knowledge of the decline in plants and animal species. No other model variables are significantly related to the probability of a "no response" answer. The final chapter discusses conclusions and policy implications of the empirical results. It also presents suggestions for future research.

Chapter V

Summary and Conclusions

Nonmarket valuation estimates the value of goods for which there are no functioning markets which reflect the benefits associated with the commodity. A variety of nonmarket valuation techniques have been devised to measure the benefits of such goods, directly or indirectly. Indirect valuation techniques, including the travel cost and hedonic pricing methods, can be used to estimate use values. Direct valuation techniques, such as the contingent valuation method, are better able to estimate nonuse values. Nonuse values, also known as passive use values, include bequest value, the value of preserving a good for posterity, and existence value, the value of knowing a good or amenity exists regardless of one's intent to use it.

Past studies of wildlife existence value have addressed the value of preserving a single species. As environmental management shifts from the protection of single species habitat to a broader ecosystem approach, nonmarket valuation techniques must similarly expand the scope of the goods for which it estimates value. Among the more comprehensive ecosystem functions which nonmarket valuation may estimate is biological diversity, the variety of plants, animals, and other species of organisms.

The total value of biodiversity includes consumptive use value, nonconsumptive use value, option value, and passive use values. Biodiversity's use values can be either direct, as in the taking or observation of elements of biodiversity, or indirect, as in providing support to ecological functions which generate benefits. Option values are the benefits of preserving a commodity for future agricultural, pharmaceutical, industrial, or commercial use. The passive use values of biodiversity emanate from the value of knowing that diverse mixture of organisms exists within an ecosystem or higher ecological organization unit.

Application of nonmarket valuation to the benefits of biodiversity must address the challenges presented by the complexity of the good. Among the conditions established for the operation of contingent valuation is that respondents understand the amenity being valued. The valuation of biodiversity depends upon the development of a conceptual model which can present biodiversity in a manner which is both comprehensible to the questionnaire respondent and ecologically meaningful.

To aid understanding, biodiversity can be broken down into components including level of diversity (i.e., genetic, species, ecosystem, or taxomic) and scope of diversity (i.e., local, inter-ecosystem, or global.) Biodiversity can be also be interpreted in terms of the roles played by species or groups of species. Keystone species, umbrella species, and other bioindicators can be used to measure the status of the diversity of species in the ecosystem. Structural species create the physical structure of the environment and exert a major influence on the diversity of other organisms.

An understanding of the components of biodiversity can be used to control the conditions which generate biodiversity. These conditions can be more easily provided by wildlife managers and understood by individuals. The valuation of biodiversity can be estimated in terms of these conditions.

Objectives of the Study

The general objective of this research was to contribute to the conceptual and procedural development of non-market valuation in order to estimate the passive use value of biodiversity. This research was designed to identify and review literature in the field of nonmarket valuation, develop a conceptual model of biodiversity passive use values, to test empirically the conceptualized model, and to suggest possible policy implications based upon the empirical analysis. The following section presents the procedures by which these objectives were achieved.

Previous Research

The review of previous literature revealed the theoretical and conceptual background of the contingent valuation method. The valuation of biodiversity was examined using utility maximization theory and Hicksian measures of value. Based upon the recommendations of the NOAA Blue Ribbon Panel (Arrow, *et al.*, 1993), Cummings, Brookshire, and Eubanks (1986), and other researchers, this research employs the willingness to pay format for an incremental increase in the provision of habitat for biodiversity. It also presents the reasons for the selection of the dichotomous choice payment elicitation format. The measure of economic welfare estimated by the dichotomous choice willingness to pay format is a Hicksian compensated variation.

This research also identified economic and ecological factors pertinent to biodiversity. The decline in biodiversity is the result of the conversion of habitat to human productive purposes, such as agriculture, timber, housing, and other. The externalities of biodiversity loss, including the deterioration of ecological services and potential ecosystem instability, are discussed.

Based upon the theoretic relationship between habitat area and species diversity (Wilson, 1992), Rowthorn and Brown (1996) developed a dynamic model for the depletion of biodiversity. This research applies the concept of modeling biodiversity as a function of habitat area in its estimate of passive use value.

Conceptual Model

This research presented a conceptual model in which the value of biodiversity was approximated by measuring the willingness to pay to preserve the conditions which generate a diversity of species. The protection of natural habitat has been established as a key factor in the preservation of biodiversity by scientific theory (Wilson, 1992; Heywood and Watson, 1992) and wildlife management practices (Beattie, 1996). Valuing biodiversity in terms of the land use practices which maintain a diversity of plant and animal species presents the issue in a form which is comprehensible to the survey respondent (Belden and Russenello, 1995; Kiker, 1996) and is relevant to the factors under the control of wildlife managers and environmental policy makers (Beattie, 1996).

In developing a model for the valuation of local species diversity in the Tensas River basin, this research identified the conditions which are used to preserve biodiversity within the specific location. The preservation of an area of bottomland hardwoods sufficient to maintain the diversity of species within the ecosystem was presented in terms of the acreage necessary to support an umbrella species, a specific neo-tropical bird (Pashley, 1997; Hamilton, 1997). The name of the species was not mentioned to prevent the valuation of the bird species itself rather than the diversity of species which occur within its habitat range.

Theoretical Model

This research developed a theoretical model based on the conceptual model for biodiversity passive use values. The theoretical model hypothesized that the value for biodiversity would vary with outdoor recreational activities, socioeconomic variables, and environmental attitudes and beliefs. Environmental attitudes and beliefs include general environmental attitudes, as measured by the New Ecological Paradigm, and specific attitudes regarding the issues which influence biodiversity, i.e., habitat loss and species decline.

Based on the recommendation of Arrow, *et al.* (1993) the willingness to pay question featured three responses: yes, no, and uncertain. The dependent variable in the dichotomous choice elicitation is a binary qualitative choice model. Negative responses are defined as any of the non-positive responses. Each dichotomous choice willingness to pay question featured one of seven randomly assigned dollar amounts: $1, $5, $10, $25, $50, $100, or $150. Mean willingness to pay is estimated by measuring the area under the curve modeling the probability of a positive response to the willingness to pay question as a function of the random dollar amount presented in the questionnaire.

In addition, this research addresses the proper sample to be used in passive use value estimation. Previous literature has investigated the issue of including a user group in the estimation of passive use of a resource, a beach, which had an established nonconsumptive use value, recreation (Silberman, Gerlowski, and Williams, 1992). This

Empirical Results

This research estimated passive use values for two samples identified as users or nonusers. Willingness to pay was estimated using a binary choice dependent variable by probity likelihood estimation. Based on random utility models (Hanemann, 1984), the probit models estimated the probability of a positive response as a factor of outdoor recreational preferences, socioeconomic variables, awareness and concern for bioidversity related issues, and two factors of the NEP.

In an additional econometric exercise, this research differentiated between the separate components of the non-positive response. Using a multinomial logit model, the factors hypothesized to influence the probability of a positive, negative, or uncertain response were analyzed. The results of the multinomial logit model were used to analyze the selection processes among three choice variables: yes, no, and uncertain.

Data used to evaluate the models were collected via a mail survey of Louisiana, Arkansas, and Mississippi residents as well as participants in a hunting permit lottery in the Tensas River National Wildlife Refuge. The mail survey was conducted according to the guidelines established in the Dillman Total Design Method (1991). Of the 4,395 mailed, 1,580 were returned for an overall return rate of 36.0 percent. Of the general population sample, 942 were returned for a subsample response rate of 30 percent. Of the Tensas hunting lottery sample, 638, or 47.2 percent, were returned.

To test the appropriateness of including resource users in passive use value estimation, two samples were created: a user group and a non-user group. The user group was defined as all respondents from the Tensas hunting lottery sample plus all respondents

To test the appropriateness of including resource users in passive use value estimation, two samples were created: a user group and a non-user group. The user group was defined as all respondents from the Tensas hunting lottery sample plus all respondents from the general population sample who had visited either of the parks located within the Tensas River basin. Due to item nonresponse and protest bid omissions, only 471 of 681 observations from the user group and 532 of 909 observations were used in the non-user group. The mail survey gathered data on outdoor recreational preferences, public opinion questions including environmental issues, willingness to pay, the New Ecological Paradigm, and eight socioeconomic variables.

Probit Models

The probit models estimating the passive use values of biodiversity habitat preservation significantly explained the respondents' decision to respond affirmatively to the dichotomous choice willingness to pay question in both the user and the nonuser sample. The model correctly predicted the choice selection for approximately 75 percent of the respondents in both the user and nonuser sample. The mean willingness to pay was \$36.84 for the nonuser sample. Depending on functional form the mean willingness to pay for the user sample was estimated as \$7.29 or \$30.57.

The relatively large portion of insignificant explanatory variables in the user sample compared to the nonuser sample indicated that the models for this sample were structurally different. The source of structural difference was probably misidentification of the value being estimated. The value provided by the user sample was likely an amalgamation of use value and passive use value. Due to the imprecision of the value estimate, the user sample was dropped from the analysis of the passive use value estimation of biodiversity habitat reservation.

In the nonuser model, a significant effect on the value of biodiversity was exerted by environmental attitudinal variables, economics variables, and socioeconomic variables. Among the attitudinal variables, the importance of the loss or development of natural places, knowledge of the decline in the number of plant and animal species, and attitudinal beliefs regarding the fragility of the balance of nature were positive and significant. The effect of education and income was positive and significant. The willingness to pay for biodiversity habitat preservation was negatively associated with the number of minor children in the household. The negative and significant effect on the probability of a positive answer of the randomly assigned dollar amount on the questionnaire was consistent with economic theory.

Multivariate Logit Model

The multivariate logit model used to examine the selection choice among three alternatives, overall, significantly explained the decision of respondents in the nonuser sample. The multivariate logit model correctly predicted 58 percent of the selection decisions. The effect of the parameters which influenced the probability of a positive answer in the multinomial logit model were identical to those in the probit model. The factors which influenced the probability of a negative answer carried a sign opposite to that which the same variables carried for the probability of a positive response. One variable measuring environmental ethical attitude, anti-anthropocentricism, which was not significantly related to the probability of a positive response in either model was negatively and significantly related to the probability of a negative response in the multinomial model. For the probability of a uncertain response, the importance of the development or loss of natural places was the only significant explanatory variable.

Conclusions

The passive use value estimated from the nonuser group, $36.84 per household, indicates that households in Louisiana do value wilderness preservation apart from its recreational benefits or its potential for agricultural, industrial, or commercial production. These results can be used to inform environmental policy makers that the public does value land set aside for the continued existence of the diversity of species which inhabit natural areas.

The estimate derived from the nonuser group must be examined in light of the limitations pertaining to dichotomous choice contingent valuation uncovered in previous literature. Like most contingent valuation estimates, this dollar value is subject to certain upward biases. These biases are attributed to the characteristics of the survey sample and the nature of the contingent valuation method.

The sample itself was characterized by more men and more men than the population of the states included in the sample area. Average incomes and level of education were higher than the representative population. These sample misrepresentations, typical of many mail surveys, may contribute to upward bias in the estimate of passive use value.

Contingent valuation estimates, particularly those from dichotomous choice elicitation formats, have been found to be larger than actual payments for nonmarket goods

(Kealy and Turner, 1993). Contingent valuation is subject to "yea saying" or "warm glow" effect, the provision of a positive response which does not reflect the true value of the commodity to the respondent (Arrow, *et al.*, 1993). Thirty seven percent of the general population sample respondents who provided positive answers indicated that their response may be the product of "yea saying' or "warm glow" effects. Despite these upward biases, the contingent valuation method can reveal useful information regarding resource valuation, for example, how the value of a nonmarket good varies in response to changes in explanatory variables (Arrow, *et al.*, 1993).

Policy Implications

The empirical analysis of the conceptual model presented in this research can be used to suggest possible policy implications. These results can contribute to the analysis of land acquisition decisions, wildlife refuge and habitat management, and ecological or environmental policy.

Because the conversion of land to other productive purposes is the main factor contributing to the depletion of biodiversity, the protection of natural areas is an effective tool for the preservation of a variety of plant and animal species. The conceptual model presented in this research estimates the value of biodiversity in terms of one variable controlled by wildlife managers and policy framers. The advantage to this approach is its direct application to current biodiversity management practices. The valuation is conducted in terms founded on ecological principles, comprehensible to the respondent in the contingent valuation market, and relevant to wildlife planners and managers.

Recent trends in wild habitat management has introduced market based incentive measures to complement government mandate oriented preservation practices (Olson, 1996). Some private conservation organizations active in the Tensas River basin, such as The Nature Conservancy, protect sensitive natural areas by purchasing lands for protection within the ecosystem among other practices (Creasman and Swan, 1992). A public program, Partners in Wildlife, encourages voluntary cooperation by local landowners to practice wildlife preservation techniques (U.S. Natural Resource Conservation Service, 1995). The exhibition of passive use values can be used to select acquisition and management policies which benefit biodiversity. The sign and significance of the variables in the empirical model, in addition, can be used to analyze trends in passive use values in response to attitudinal and demographic changes.

The empirical insignificance of outdoor recreation preferences can help resource managers allocate resources in the face of a trend away from consumptive toward nonconsumptive recreational activities (Mangun, O'Leary, and Mangun, 1992). The insignificant sign for the hunting variable suggests that passive use values will not decline as the popularity of hunting declines. Similarly, the insignificant sign on the nonmotorized, nonconsumptive recreational activities suggest that passive use values will not rise as the participation in such activities rises. This could assist wildlife managers in their decisions to manage natural areas. On this basis, wildlife managers could consider management practices which maintain diversity in addition those meant specifically to support recreational activities.

Knowledge of the term "biodiversity" was not a significant explanatory factor in the valuation of biodiversity habitat preservation but knowledge of the decline in species was significant. This suggests that policy framers wishing to increase the demand for habitat preservation should educate the public of the upward global and local trend in extinction without focusing on the technical term, "biodiversity". With wider public awareness, increased demand for habitat preservation may reduce the rate of habitat conversion.

Implications can be drawn from the significance of two environmental attitudinal variables, the loss of places and nature and attitudes about the fragility of the balance of nature. These variables imply that willingness to pay for biodiversity habitat preservation increases among individuals who believe that the interruption of natural processes by human actions may damage or upset ecological functions. The insignificance of the attitude variable measuring anti-anthropocentric beliefs indicates that the value of biodiversity habitat preservation is not strongly connected to ethical concepts which assign to non-human species rights and considerations usually reserved for human beings. Policy framers and natural resource managers may wish to present the value of biodiversity to the public in terms of the contributions of biological diversity maintenance to ecological stability.

The negative and significant sign on the household size parameter suggests that the value of biodiversity preservation varies inversely with the number of household members under the age of eighteen. Internationally, as population grows, this suggest that the value preserving natural areas for biodiversity will decline.

The significance of education suggests that the value of biodiversity habitat preservation rises as the level of formal education among members of the population increases. Similarly, the significance of the income parameter suggests that biodiversity habitat preservation is a normal good for which the value will rise as incomes across the state rise.

Future Research

This research estimated the passive use value of local, or α, species biodiversity in the Tensas River basin by estimating the willingness to pay for the preservation of an area of bottomland hardwoods sufficient to maintain the diversity of species within the ecosystem. Because the Tensas River basin is only a portion of a larger ecosystem, the value of its α-diversity is likely a portion of the value of the global, or γ, diversity of the Lower Mississippi River Valley, or Alluvial Plain. Future research should address the value of this wider scope of biological diversity.

Future research may address the value of preserving the biodiverse resources within a number of different ecological community types within the Lower Mississippi River Valley. Research could examine whether willingness to pay differs for a variety of wetlands or forests types which lie along the range of the ecosystem (Dillman, Beran, and Hook, 1993) . Future reference could also measure the value of preserving biodiversity "hot spots", relatively small areas of a high degree of localized diversity (Bourgeron, *et al.*, 1995; Nature Conservancy of Louisiana, 1997), which are used in conjunction with larger continual habitat preservation, like the one used in this research. Simpson, Sedjo, and Reid (1996) used hot spots in the estimation of the option value of biodiversity protection by pharmaceutical firms. The estimation of passive use values for hot spots in the Lower

Mississippi River valley would contribute to the broader measure of value of habitat preservation in the ecosystem.

The construction of wildlife corridors, relatively narrow strips of natural areas connecting large areas, could aid both species and genetic diversity by permitting migration between the areas. This function allows the improvement of inter-ecosystem, or β, diversity (Heywood and Watson, 1995). An estimation of this measure of diversity could be estimated in future research by referring to such a program.

The migration of neo-tropical birds through the Tensas River basin allows another opportunity for the measurement of β-diversity. Because birds migrate both within the Lower Mississippi Valley and across other ecosystems, this measure of β-diversity would be even broader than that provided by the migration along wildlife corridors. The decline in bird species has brought special attention in the scientific community and the wider public (Stotz, *et al.*, 1996). It has provided a venue for the estimation of nonconsumptive use values of biodiversity (Steffens and Hoehn, 1997). An estimation of the value of the diversity in this taxon is a fertile area for future research.

This research has estimated the value of the passive use values. Past research has estimated the option value (Simpson, Sedjo, and Reid, 1996) and nonconsumptive use value (Steffens and Hoehn, 1997) of biodiversity. Future research can contribute to the understanding of the value of biodiversity by measuring the value of biodiversity to ecosystem functions. A measure of indirect use value of biodiversity requires the assistance of other disciplines in the identification and specification of biodiversity's ecosystem function.

Future research should address the different means of biodiversity preservation. Although habitat preservation is seen as the principle method to protect biodiversity, other efforts may be used to protect elements of biodiversity sensitive to various ecological pressures. Aquatic biodiversity preservation may require the restoration of water flow (Pendergrass, 1996) and reduction of pollutants (Vidrine, 1996). Similarly, the reduction of pollutants and alteration of unsustainable harvesting practices are important in the preservation of marine biodiversity (Costanza, Kemp, and Boynton, 1995; Iudicello, 1996). Terrestrial biodiversity is also affected by pressure from exotic species (Jenkins, 1996), pollutants, and other factors. Willingness to pay for the control of factor adversely affecting biodiversity is an area for future research.

This research, conducted in the neoclassical microeconomic framework, is utilitarian, anthropocentic, and instrumentalist in its foundations (Randall, 1988). Microeconomics research adopts a positive perspective to describe individual preferences and explain individual behavior. The economic standard of efficiency is applied within a particular institutional and ethical structure (Hanemann, 1988). Other analytical approaches which examine the institutional and ethical structures can provide insight into the value of biodiversity. This research acknowledges the existence of other standards outside economics which provide viable perspectives on the value of biodiversity.

Because biodiversity is distinguished by nonexclusive, nonrival property rights (Randall, 1991b), it may be examined according to disciplines which address collective behavior like law and political science. One such analytical framework, the public trust doctrine, holds that certain amenities belong to society and are administered and managed by the government elected for that purpose. If the public trust doctrine is relevant to biodiversity, biodiversity protection may be a political matter, a right of sorts guaranteed to citizens. From this perspective, valuing biodiversity according to willingness to pay may be as irrelevant as using the same perspective to value free speech, elected representation, or any other political right (Johnson and Galloway, 1996; Loomis. 1989).

Even as a public trust amenity, biodiversity is still affected by the economic concepts of scarcity and preferences. Due to resource scarcity, the provision of one public trust amenity may conceivably interfere with the provision of another desirable amenity. Selections regarding the provision of public trust goods must be made according to a set of preferences. Preferences for public goods, like conservation, differ across nations (Henderson, 1992). Conservation arguments can be factored into a political choice model (Rausser and Zusman, 1992) or other collective choice analytical framework.

Another alternative perspective concerns the ethical issues of biodiversity depletion. Even if nonhuman species do not possess intrinsic value, it is possible to question the morality of actions which permanently destroy distinct, unique, and irreplaceable entities to satisfy seemingly insatiable human desires (Sagoff, 1997). The need to classify the value of biodiversity in terms of imperfect human institutions, like monetary units, markets, and other societal structures, may be philosophically and ethically void (Daly and Cobb, 1994; Norton, 1988; Ehrenfeld, 1988).

Ethical standards can be difficult to apply because of competing moral attitudes and conflicts obligations. In order to preserve all elements of biodiversity, trade offs must be made which may involve the compromising other ethical or moral positions. Economics provides a structure which allows these trade offs to be taken into consideration (Randall, 1991b).

From the more objective perspectives of scientists, including ecologists, conservation biologists, and others, it is possible to question the efficacy of entrusting to individuals the valuation of an amenity which may be beyond the limits of human cognition. Science is incapable of describing the complex set of interactions of the myriad species on the planet or the ecological consequences of interrupting natural processes on a wide and pervasive scale. Leopold (1966) argued that humans should retain all the "cogs and wheels" of natural systems as necessary to the perpetuation of ecological systems. To date, ecosystem collapse has not been precipitated by the extinction or extirpation of even prominent individual species, like the American chestnut (Ehrenfeld, 1988), whales (Sagoff, 1997), or the passenger pigeon (Ward, 1994). As the current trend in the extinction rate accelerates, the consequences are uncertain.

Biological diversity has been rising slowly across the span of natural history with period setbacks called extinction spasms. There have been five of these episodes since the beginning of life on the planet to the origin of humanity. The current trend in extinctions has been called the sixth extinction spasm. It is sobering to think, claim some ecologists, that the species which were dominant at the beginning of the extinction spasm were no longer dominant at its end (Wilson, 1992; Ward, 1994).

Although biological diversity does support certain ecological functions, it is not necessarily true that the continued depletion of biological diversity will prompt ecological collapse (Randall, 1991b). Some scientists contend that much of the concern regarding the conservation of biodiversity is alarmist, based on scant scientific evidence (Nelson and Serafin, 1992). Many natural systems feature redundancies which provide stability in the face of ecosystem change. Large expenditures on ecologically marginal species may not be economically or ecologically justified (Norton and Ulanowicz, 1992).

Economic theory can provide useful information about the issue of biological diversity. This research has applied economic techniques to address one portion of the biodiversity issue. It has estimated one component, passive use value, of a policy intended to preserve the diversity of species in one community or ecosystem within a larger ecosystem among many ecosystems throughout the world. This research has demonstrated that willingness to pay for biodiversity habitat preservation in a bottomland hardwoods forest varies with attitudinal, economic, and socioeconomic variables.

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Appendices

Appendix A

Data Collection Procedures

APPENDIX A.1

Correspondence Mailed to Survey Recipients

May 22, 1997

Dear Sir or Madam:

Louisiana's bottomland hardwood wetlands are considered by some people to be a great national resource. Because they provide benefits to people both inside and outside Louisiana, protection of these areas has become a priority at the state and national level. Proper management of these resources can ensure that there are still wild areas available for hunting, fishing, and other recreational uses, as well as habitat for a variety of plants and animals.

The Louisiana State University Department of Agricultural Economics and Agribusiness requests your help in examining wild resource preservation in an area of Louisiana. You are among a select group of people chosen for participation in this study. For this study to be truly representative, it is important that this survey be completed and returned by you.

You may be assured of complete confidentiality. The identification number that appears on this questionnaire is for mailing purposes only, allowing us to check your name off the mailing list when your questionnaire is returned. Your name will never be connected with your answers in any way. You may request a summary of this survey by writing "results requested" on the return envelope along with your name and address. Please do not put this information on the questionnaire itself.

We would be pleased to answer any question you may have about this questionnaire. Additional information and answers to any question you may have can be obtained by calling the LSU research team at (504) 388 - 2763.

Thank you for your assistance.

Sincerely,

E. Jane Luzar
Professor

June 3, 1997

Dear Sir or Madam:

Recently a questionnaire seeking information about your views regarding the benefits of habitat preservation was mailed to you. This card is a reminder please to fill out the questionnaire. If you have already completed it and mailed it back to us, please accept our thanks. If not, please do so today. It is extremely important that your questionnaire be completed in and returned by you so that the results of this study will be truly representative. If by some chance you did not receive the questionnaire, or it has been misplaced, please call me att (504) 388 - 2763 and another will be sent to you immediately.

Sincerely,

E. Jane Luzar
Professor

June 17, 1997

Dear Sir or Madam:

About three weeks ago, I sent you a questionnaire seeking your views on habitat preservation. As of today, I have not received your completed questionnaire.

I am writing to you today because of the importance each questionnaire has to this research. Your name was chosen through a random selection process in which every resident of Louisiana, Mississippi, and Arkansas had an equal chance of being selected. In order for this study to be truly representative, it is important that each person return the questionnaire.

I am enclosing another copy of the Louisiana Wild Habitat Conservation Survey questionnaire in case your original copy has been misplaced. Your answers to this questionnaire will be held completely confidential and will be used only for the purpose of this study.

If you have already filled in and mailed back your questionnaire, please disregard this reminder and accept our thanks for participating in this study.

Any additional information and answers to any question you may have can be obtained by calling the LSU research team at (504) 388 - 2763.

Sincerely,

E. Jane Luzar
Professor

Appendix A.2

Lower Mississippi Valley Plant and Wildlife Survey

Section 1 OUTDOOR RECREATIONAL ACTIVITIES

In this section, we would like to ask about your participation in outdoor recreation, for example, hunting, fishing, hiking, and boating.

Q-1. Please indicate whether you participated in any of these activities during 1996. (Please circle **ALL** that apply):

1 Freshwater Fishing
2 Saltwater Fishing
3 Hiking
4 Bird Watching
5 Photographing or Observing Wildlife or Natural Areas
6 Canoeing or Rowing
7 Motor-Boating or Water-Skiing
8 Camping
9 All Terrain Vehicle (ATV) Driving
10 Jet Skiing
11 Big Game Hunting (for example, Deer, Elk, and Wild Boar)
12 Small Game Hunting (for example, Squirrels and Rabbits)
13 Waterfowl Hunting
14 Turkey Hunting
15 Other Types of Hunting:
(Please specify ________________________________)
16 I did not participate in any of these activities.

The next three questions ask about your hunting experience. If you did not hunt in 1996, please skip to question Q-5.

Q-2. Which of the following best describes your hunting skills? (Please circle the number)

1 Beginner
2 Intermediate
3 Advanced
4 Expert

Q-3. Which of the following best describes the land on which you hunted in 1996? (Please circle **ALL** that apply.)

1 Land that I own
2 Land that I lease
3 Land that a friend or relative owns
4 State managed land
5 Federal managed land
6 Other ______________________________

Q-4. In what state or states did you hunt during 1996? (Please write the name of the state.)

1 ____________ 4 ____________ 7 ____________

2 ____________ 5 ____________ 8 ____________

3 ____________ 6 ____________ 9 ____________

The next three questions ask about your fishing experience. If you did not fish in 1996, please skip to question Q-8.

Q-5. Which of the following best describes your fishing skills? (Please circle the number)

1 Beginner
2 Intermediate
3 Advanced
4 Expert

Q-6. Which of the following best describes where you fished in 1996? (Please circle **ALL** that apply.)

1 Coastal marshes
2 Lakes or reservoirs
3 Rivers, streams, or bayous
4 Farm ponds
5 Inshore saltwater
6 Offshore saltwater
7 Other ______________________________

Q-7. In what state or states did you fish during 1996? (Please write the name of the state.)

1 ____________	4 ____________	7 ____________
2 ____________	5 ____________	8 ____________
3 ____________	6 ____________	9 ____________

The next three questions ask about your experiences with other forms of outdoor recreation. If you did not participate in any forms of outdoor recreation in 1996, please skip to question Q-11.

Q-8. Which of the following best describes your skill at nonmotorized outdoor recreational activities, such as hiking, canoeing, and bird watching? (Please circle the number)

1 Beginner
2 Intermediate
3 Advanced
4 Expert

Q-9. Which of the following best describes the area in which you took part in outdoor recreation besides hunting and fishing in 1996? (Please circle **ALL** that apply.)

1 Land that I own
2 Land that I lease
3 Land that a friend or relative owns
4 State managed land or parks
5 Federally managed land or parks
6 Coastal marshes
7 Lakes or reservoirs
8 Rivers, streams, or bayous
9 Ocean or beach
10 Other ______________________________

Q-10. In what state or states did you take part in these activities during 1996? (Please write the name of the state.)

1 ______________	4 ______________	7 ______________
2 ______________	5 ______________	8 ______________
3 ______________	6 ______________	9 ______________

Q-11. Did you visit the Big Lake Wildlife Management Area near Winnsboro, Louisiana during 1996?

1 Yes
2 No
3 I don't know

Q-12. Did you visit the Tensas River National Wildlife Refuge (NWR) near Tallulah, Louisiana during 1996?

1 Yes
2 No
3 I don't know

The next two questions ask about your experience at the Tensas River NWR. If you did NOT visit the Tensas River NWR, please skip to Q-15.

Q-13. In what types of activities did you take part at the Tensas River NWR during 1996? (Please circle **ALL** the numbers that apply.)

1 Hunting
2 Fishing
3 Environmental Education
4 Bird Watching
5 Wildlife Watching
6 Outdoor Photography
7 Hiking
8 ATV use
9 Other ______________________________

Q-14. Please indicate how important each of the public activities at the Tensas River NWR is to you. (Please circle your response.)

NO = Not Important At All; **NI** = Not Very Important; **SI** = Somewhat Important; **VI** = Very Important

		Not Important At All	Not Very Important	Somewhat Important	Very Important
a.	Hunting	NO	NI	SI	VI
b.	Fishing	NO	NI	SI	VI
c.	Environmental Education	NO	NI	SI	VI
d	Bird Watching	NO	NI	SI	VI
d.	Wildlife Watching	NO	NI	SI	VI
e.	Outdoor Photography	NO	NI	SI	VI
f.	Hiking	NO	NI	SI	VI
g.	ATV Use	NO	NI	SI	VI

Section 2 Your Opinion on Public Issues

In this section, we would like to ask for your views about some public issues the country may be facing in the next few years.

Q-15. Please indicate what type of priority you think should be given to the following issues: (Please circle your response.)

VH = Very High priority; **H** = High priority, **L** = Low priority, **VL** = Lowest priority

		Very High Priority	High Priority	Low Priority	Very Low Priority
a.	Improving the health care system	VH	H	L	VL
b.	Cutting government spending	VH	H	L	VL
c.	Lowering crime rates	VH	H	L	VL
d.	Improving public education	VH	H	L	VL
e.	Protecting the environment	VH	H	L	VL

Q-16. In your opinion, which of the following best describes the current state of the U.S. environment? (Please circle the number)

1 Improving a great deal
2 Improving somewhat
3 Staying the same
4 Getting somewhat worse
5 Getting a great deal worse

Q-17. Thinking specifically about environmental issues, how important is each of the following issues? (Please circle your response)

NO = Not Important At All; **NI** = Not Very Important; **SI** = Somewhat Important; **VI** = Very Important

		Not Important At All	Not Very Important	Somewhat Important	Very Important
a.	Air quality in the U.S.	NO	NI	SI	VI
b.	Water quality in the U.S.	NO	NI	SI	VI
c.	Toxic waste in the U.S.	NO	NI	SI	VI
d.	Acid rain in the U.S.	NO	NI	SI	VI
e.	Global climate change	NO	NI	SI	VI
f.	Loss of rain forests	NO	NI	SI	VI
g.	Over-consumption of resources in the U.S.	NO	NI	SI	VI
h.	The rate at which land is being developed and places in nature are being lost	NO	NI	SI	VI
I.	The rate at which plant and animal species are becoming extinct	NO	NI	SI	VI

Wildlife scientists use the word **biodiversity** (short for *bio*logical *diversity*) to refer to the **whole variety of living things**, including the wide range of animals, plants, birds, insects, fish, and other forms of life on Earth.

Q-18. Have you previously heard of the word biodiversity? (Please circle the number)

1 Yes
2 No
3 I don't know

Q-19. In your opinion, which term best describes what is happening with the number of plants and animal species in the world? (Please circle the number)

1 Increasing
2 Decreasing
3 Staying the same
4 I don't know

Q-20. What do you think is the main reason plant and animal species become extinct? (Please circle the number)

1 Mostly natural causes
2 Mostly human actions
3 Natural causes and human actions, about equally
4 I don't know

Section 3 LOWER MISSISSIPPI RIVER VALLEY ECOSYSTEM

The Lower Mississippi Valley Ecosystem stretches along the Mississippi River from the southern tip of Illinois to just south of New Orleans, Louisiana. Typical of this ecosystem is the Tensas River Basin, an area of about 680,000 acres in northeast Louisiana. Like the whole Lower Mississippi Valley, **most of this area has been converted to agriculture, industry, and housing.**

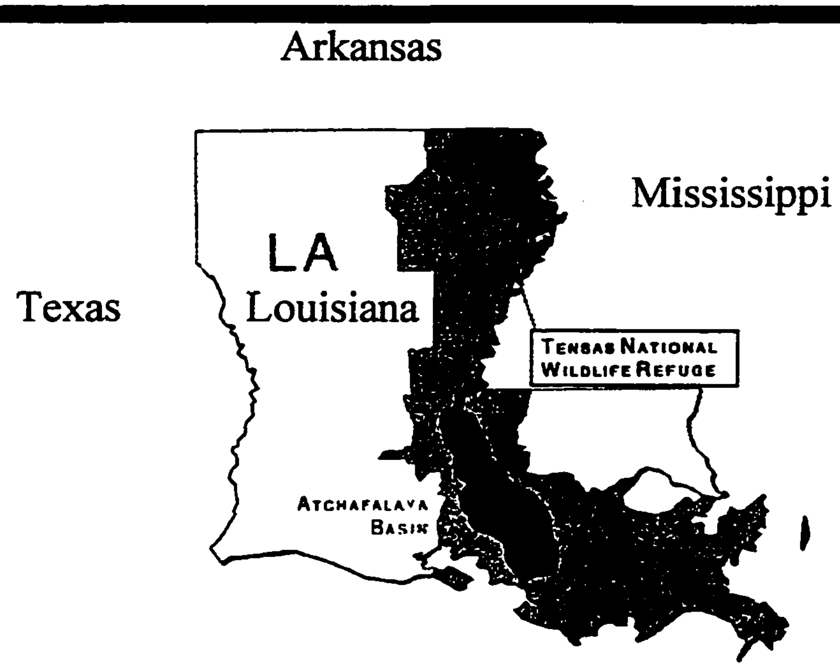
The Tensas River Basin contains a habitat called **bottomland hardwoods**, a type of wetlands consisting mainly of forests of tall trees. It supports a wide variety of plants and animals. Among **the many other types of plants and animals**, the area includes approximately:

- 6 species of pine and cedar trees
- 10 species of lilies
- 75 species of fish
- 110 species of grasses
- 20 species of snakes
- 200 species of birds

The Tensas River Basin is one of the few areas in the Lower Mississippi Valley that has enough remaining bottomland hardwoods to maintain the diverse mixture of plants and animals in the ecosystem.

Tensas River National Wildlife Refuge, Tallulah, Louisiana

The **Tensas River National Wildlife Refuge** (see map) is a 64,000 acre area inside the Tensas River Basin. It is managed by the U.S. Fish and Wildlife Service which acts in cooperation with local governments, state agencies, land owners, and local residents to preserve habitat for plants and wildlife. The Refuge is a center of efforts to enhance the land available as habitat for plant and wildlife.



Wildlife scientists seek to enhance the diversity of plants and animals in the Tensas River basin by protecting the forested wetlands they use as habitat. By expanding the area set aside as natural habitat, they plan to **increase the number of different plant and animal species** in the Tensas River basin as well as **increase the population of those species that are already there.**

Wildlife scientists calculate how much land to preserve as natural habitat for the variety of plants and animals in an ecosystem by focusing on the size of the area needed to support a particular species with large habitat needs. If there is enough land set aside as natural forest habitat for this species, they figure, there would be enough to maintain the other species of plants and animals, too. Using a species of bird which needs a wide area of forest to survive, scientists think that increasing the area of protected natural forests from the **88,000 acres** available right now to **100,000 acres** would support this species and all the other **species of plants and animals in the Tensas River basin.**

A voluntary fund has been proposed to acquire enough forested wetlands in the Tensas River basin to support the **variety of plants and animals** that occur in the habitat. This fund, if established, would purchase land, coordinate resources, and use existing public and private programs to increase the size of natural forest habitat in the Tensas River basin from about **88,000** acres to **100,000** acres and manage the land scientifically to maintain the variety of plants and animals in the ecosystem.

Q-21. Would you be willing to pay $5 from your household budget into a voluntary fund **each year** to restore habitat for the variety of plant and animal species in the Tensas River basin **just for the knowledge that they exist?** (Please circle the number)

1 Yes
2 No
3 I am not certain

Q-22. If you answered NO to question 21, please mark the reason that **best** describes why you answered NO. [If you answered YES to question 21, please skip to question 23.] (Please circle the number)

1 It would be worth some smaller amount to me.
2 It would be worth nothing to me.
3 People should not have to pay for the restoration or conservation of wild habitat or ecosystems.
4 I cannot afford to pay for the restoration or conservation of wild habitat or ecosystems.
5 I object to the question.
6 Other (Please specify.) ________________

Q-23. If you answered YES to question 21, please mark the reason that **best** describes why you answered YES. (Please circle the number)

1 It would be worth that much to me to increase the size of habitat to increase the number of species of plants and animals.
2 That is all I have available to give at this time.
3 It makes me feel good to give to worthy causes.
4 People should help preserve wild habitat and ecosystems, and I feel this is my "fair share."
5 That is the amount I give to all causes that I believe in.

Section 4 ENVIRONMENTAL ATTITUDE ASSESSMENT

In this section, we would like to learn more about your attitudes towards the environment.

Q-24. Please indicate whether you agree or disagree with the following statements about the environment: (Circle your response)

SA= Strongly Agree, A=Agree, U= Uncertain, **D**= Disagree, **SD**= Strongly Disagree.

		Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
1	We are approaching the limit of the number of people the earth can support.	SA	A	U	D	SD
2	Humans have the right to modify the natural environment to suit their needs.	SA	A	U	D	SD
3	When humans interfere with nature it often produces disastrous consequences.	SA	A	U	D	SD
4	Human ingenuity will ensure that we do NOT make the earth unlivable.	SA	A	U	D	SD
5	Humans are severely abusing the environment.	SA	A	U	D	SD
6	The earth has plenty of natural resources if we just learn how to develop them.	SA	A	U	D	SD
7	Plants and animals have as much right as humans to exist.	SA	A	U	D	SD
8	The balance of nature is strong enough to cope with the impacts of modem industrial nations.	SA	A	U	D	SD
9	Despite our special abilities, humans are still subject to the laws of nature.	SA	A	U	D	SD
10	The so-called "ecological crisis" facing humankind has been greatly exaggerated.	SA	A	U	D	SD
11	The earth is like a spaceship with very limited room and resources.	SA	A	U	D	SD

		Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
12	Humans were meant to rule over the rest of nature.	SA	A	U	D	SD
13	The balance of nature is very delicate and easily upset.	SA	A	U	D	SD
14	Humans will eventually learn enough about how nature works to be able to control it.	SA	A	U	D	SD
15	If things continue on their present course, we will soon experience a major ecological catastrophe.	SA	A	U	D	SD

Section 5 PERSONAL CHARACTERISTICS

Q-25. What is your gender? (Please circle the number)

1 Male 2 Female

Q-26. What is the highest level of education you have completed? (Please circle the number)

1	Some Grade School	4	Some College
2	Some High School	5	Completed College
3	Completed High School	6	Advanced Degree

Q-27. Which of the following best describes your racial or ethnic background? (Please circle the number)

1 American Indian
2 Asian or Pacific Islander
3 Black (African American)
4 Hispanic
5 White (Caucasian)

Q-28. Which of the following best describes your area of residence? (Please circle the number)

1 Farm or open country
2 Towns under 10,000 people
3 Towns and Cities 10,000 to 50,000 people
4 Suburbs of city of over 50,000 people
5 Central city of over 50,000 people

Q-29. What is your present age?

__________ years

Q-30. How many persons live in your household, including yourself?

__________ persons

Q-31. Of the people living in your house, how many are less than 18 years old?

__________ persons

Q-32. Which of the following best describes your total household income for 1996? (Please circle the number)

1 LESS than $15,000
2 $15,000 to $24,999
3 $25,000 to $34,999
4 $35,000 to $49,999
5 $50,000 to $74,999
6 $75,000 to $99,999
7 OVER $100,00

SECTION 6 SUGGESTIONS

If you have any comments about wildlife habitat conservation or comments about this survey, please write them in this section.

THANK YOU FOR TAKING THE TIME TO ANSWER THESE QUESTIONS.

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Appendix B:

Goodness-of-fit Measures and Prediction Tables

1. Aldrich and Nelson's $R^2 = R^2_{AN} = \lambda / (\lambda + N)$

where $L(0)$ = restricted maximum log likelihood statistic under the assumption that $\beta_i = 0$ for all β_i except the intercept;

$L(\beta)$ = 2[L(0) - L(β)]lihood statistic from the log-likelihood sample size. he probit model;

λ = $2[\, L(0) - L(\beta)\,]$;

N = sample size.

(Aldrich and Nelson, 1984).

1a.) Nonuser Sample-

R^2_{AN} = 150.7352/(150.7352+532) = 0.2207813512472

1b.) User Sample -

R^2_{AN} = 177.028/(177.028 + 471) = 0.2732625758024

1c.) User Sample Modified Model -

R^2_{AN} = 183.128/674.1528 = 0.2716784681455

1d.) Mulitnomial Logit Model -

R^2_{AN} = 205.8027/731.8626 = 0.28128596

2. Veall and Zimmermann's $R^2 = R^2_{VZ} = [\lambda / (\lambda + N)] * [(2L(0) - N)/2L(0)]$ (Windmeijer, 1995).

2a.) Nonuser Sample-

$$R^2_{VZ} = \left[\frac{150.7352}{(150.7352+532)}\right]*\left[\frac{(2*150.7352 - 532)}{(2*150.7352)}\right] =$$

= [0.2207813512472]*[1.76846911162]

= 0.3904450662356.

2b.) User Sample -

$$R^2_{VZ} = \left[\frac{177.028}{(177.028+471)}\right]*\left[\frac{(2*177.028 - 471)}{(2*177.028)}\right] =$$

= [0.2732625958024]*[1.7253170455166]

= 0.471464643442.

2c.) User Sample Modified Model -

R^2_{VZ} = (0.2716784681455)*(-1168.243/-667.243) =

= 0.4686448861955

2d.) Multinomial Logit -

R^2_{VZ} = (0.28128596)*(1.45659728364) = 0.409720772

3. McFadden's R^2 or pseudo- $R^2 = R^2_{MF} = 1 - [L(\beta)/L(0)]$ (Judge, *et al.*, 1988).

3a.) Nonuser Sample -

$$R^2_{MF} = 1 - [(-250.774)/(-346.1426)] = $$
$$= 1 - 0.78206524132$$
$$= 0.217793475868.$$

3b.) User Sample -

$$R^2_{MF} = 1 - [(-236.1342)/(-324.6856)] = $$
$$= 1 - 0.727203193489$$
$$= 0.272729680651 1.$$

3c.) User Sample Modified Model -

$$R^2_{MF} = 1 -[(-247.0451)/(-338.6215)] = $$
$$= 0.2704388232879$$

3d.) Multinomial Logit -

$$R^2_{MF} = 1 - [(-473.0668)/(-575.9981)] = $$
$$= 0.1772748916413$$

4. Adjusted McFadden $R^2 = R^2_{MFA} = 1 - [L(\beta)/L(0)][(N-1)/(N-k)]$
where k = number of model parameters (Laitila, 1993).

4a.) Nonuser Sample -

$$R^2_{MFA} = 1 - [(-250.774)/(-346.1426)]*[531/518] = $$
$$= 0.1981628102045$$

4b.) User Sample -

$$R^2_{MFA} = 1 - [(-236.1342)/(-346.1426)]*[470/457]$$
$$= 0.2928456682075$$

4c.) User Sample Modified Model -

$$R^2_{MFA} = 1 -[(-247.0451)/(-338.6215)]*[490/483] = $$
$$= 0.2598654729008$$

4d.) Multinomial Logit -

$$R^2_{MFA} = 1- [(-473.0668)/(-575.8627)]*[525/498] = $$
$$= 0.134172$$

Table B.1
Prediction Table for Probit Model of the Non-user Sample

		Predicted		
		0	1	Total
Actual	0	300	43	343
	1	85	104	189
	Total	385	147	532

Table B.2
Prediction Table for the Probit Model of the User Sample

		Predicted		
		0	1	Total
Actual	0	146	69	215
	1	35	221	256
	Total	181	290	471

Table B.3
Prediction Table for the Modified Probit Model of the User Sample

		Predicted		
		0	1	Total
Actual	0	153	72	225
	1	43	223	266
	Total	196	295	491

Table B.4
Prediction Table for the Multinomial Logit Model

		Predicted			
		0	1	2	
	0	39	54	62	155
Actual	1	19	129	34	182
	2	29	24	136	189
		87	207	232	526

Appendix C:

Summary Statistics And Frequency Tables

Table C.1
Frequency Table for Respondent's Outdoor Recreational Activities

Please indicate whether you participated in any of these activities in 1996.

	Combined Sample		Tensas Lottery Sample		General Population Sample	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Freshwater Fishing	1003	63.5	567	88.9	436	46.3
Saltwater Fishing	503	31.8	228	35.7	275	29.2
Hiking	316	20.0	145	22.7	171	18.2
Bird Watching	239	15.1	99	15.5	140	14.9
Photographing or Observing Wildlife or Natural Areas	371	23.5	195	30.6	176	18.7
Canoeing or Rowing	196	12.4	105	16.5	91	9.7
Motor Boating or Water Skiing	691	43.7	398	62.4	293	31.1
Camping	654	41.4	444	69.6	210	22.3
All Terrain Vehicle (A.T.V.) Driving	571	36.1	458	71.8	113	12.0
Jet Skiing	115	7.3	51	8.0	64	6.8
Big Game Hunting	796	50.4	616	96.6	180	19.1
Small Game Hunting	747	47.3	566	88.7	181	19.2
Waterfowl Hunting	404	25.6	306	48.0	98	10.4
Turkey Hunting	229	14.5	180	28.2	49	5.2
Other Types of Hunting	95	6.0	65	10.2	30	3.2
I did not participate in any of these activities	289	18.3	5	0.8	284	30.2

Table C.2
Frequency Table for Respondents Description of Hunting Skills

Which of the following best describes your hunting skills?

	Combined Sample		Tensas Lottery Sample		General Population Sample	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Beginner	27	1.7	5	0.8	22	2.3
Intermediate	188	11.9	93	14.6	95	10.1
Advanced	554	35.2	410	64.6	144	15.3
Expert	150	9.5	112	17.6	38	4.0

Table C.3
Frequency Table for Respondent's Description of Hunting Location

Which of the following best describes the land on which you hunted in 1996?

	Combined Sample		Tensas Lottery Sample		General Population Sample	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Land that I own	175	11.1	121	19.0	54	5.7
Land that I lease	419	26.5	320	50.2	99	10.5
Land that a friend or relative owns	445	28.2	273	42.8	172	18.3
State managed land	564	35.7	479	75.1	85	9.0
Federally managed land	549	34.7	493	77.3	56	5.9
Other	55	3.5	31	4.9	24	2.5

Table C.4
Frequency Table for Participants' Hunting Site by State

In what state or states did you hunt in 1996?

State	Combined Sample	Tensas Lottery Sample	General Population Sample	State	Combined Sample	Tensas Lottery Sample	General Population Sample
	Frequency (Percent)				Frequency (Percent)		
Louisiana	819 (51.8)	610 (95.6)	209 (22.2)	Montana	1 (0.1)	0 (0.0)	1 (0.1)
Arkansas	66 (4.2)	35 (5.5)	31 (3.3)	Nebraska	2 (0.1)	2 (0.3)	0 (0.0)
Mississippi	166 (10.5)	86 (13.5)	80 (8.5)	New Mexico	1 (0.1)	1 (0.2)	0 (0.0)
Alabama	21 (1.3)	14 (2.2)	7 (0.7)	North Dakota	1 (0.1)	0 (0.0)	1 (0.1)
Colorado	41 (2.6)	25 (3.9)	16 (1.7)	Ohio	2 (0.1)	2 (0.3)	0 (0.0)
Florida	3 (0.2)	1 (0.2)	2 (0.2)	Oklahoma	2 (0.1)	2 (0.3)	0 (0.0)
Georgia	1 (0.1)	0 (0.0)	1 (0.1)	Pennsylvania	1 (0.1)	0 (0.0)	1 (0.1)
Illinois	3 (0.2)	3 (0.5)	0 (0.0)	South Carolina	1 (0.1)	1 (0.2)	0 (0.0)
Kansas	3 (0.2)	1 (0.2)	2 (0.2)	Tennessee	1 (0.1)	0 (0.2)	1 (0.1)
Kentucky	1 (0.1)	1 (0.2)	0 (0.0)	Texas	68 (0.3)	42 (6.6)	26 (2.8)
Michigan	1 (0.1)	1 (0.2)	0 (0.0)	Wyoming	1 (0.1)	0 (0.0)	1 (0.1)
Missouri	4 (0.3)	2 (0.3)	2 (0.2)	Outside the U.S.	2 (0.1)	0 (0.0)	2 (0.2)

Table C.5
Frequency Table for Respondent's Description of Fishing Skills

Which of the following best describes your fishing skills?	Combined Sample		Tensas Lottery Sample		General Population Sample	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Beginner	106	6.7	11	1.7	95	10.1
Intermediate	441	28.0	196	30.8	245	26.2
Advanced	511	32.5	318	49.9	193	20.6
Expert	106	6.7	66	10.4	40	4.3

Table C.6
Frequency Table for Respondent's Description of Fishing Location

Which of the following best describes where you fished in 1996?						
	Combined Sample		Tensas Lottery Sample		General Population Sample	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Coastal marshes	392	24.8	180	28.2	212	22.5
Lakes or reservoirs	781	49.4	462	72.4	319	33.9
Rivers, streams, or bayous	849	53.7	515	80.7	334	35.5
Farm ponds	354	22.4	223	35.0	131	13.9
Inshore saltwater	366	23.2	163	25.5	203	21.5
Offshore saltwater	226	14.3	108	16.9	118	12.5
Other	23	1.5	14	2.2	9	1.0

Table C.7
Frequency Table for Participants' Fishing Site by State

In what state or states did you fish in 1996?

State	Combined Sample	Tensas Lottery Sample	General Population Sample	State	Combined Sample	Tensas Lottery Sample	General Population Sample
	Frequency (Percent)				Frequency (Percent)		
Louisiana	1050 (66.5)	588 (92.2)	462 (49.0)	Missouri	2 (0.1)	1 (0.2)	1 (0.1)
Arkansas	80 (5.1)	27 (4.2)	53 (5.6)	Nevada	2 (0.1)	0 (0.0)	2 (0.2)
Mississippi	139 (8.8)	36 (5.6)	103 (10.9)	New York	2 (0.1)	0 (0.0)	2 (0.2)
Alabama	17 (1.1)	6 (0.9)	11 (1.2)	North Carolina	2 (0.1)	0 (0.0)	2 (0.2)
Alaska	2 (0.1)	1 (0.2)	1 (0.1)	North Dakota	1 (0.1)	1 (0.2)	0 (0.0)
Arizona	2 (0.1)	1 (0.2)	1 (0.1)	Oklahoma	2 (0.1)	2 (0.3)	0 (0.0)
California	1 (0.1)	0 (0.0)	1 (0.1)	Oregon	2 (0.1)	1 (0.1)	1 (0.1)
Colorado	7 (0.4)	4 (0.6)	3 (0.3)	South Carolina	2 (0.1)	1 (0.1)	1 (0.1)
Florida	38 (2.4)	8 (1.3)	30 (3.2)	Tennessee	3 (0.2)	0 (0.0)	3 (0.3)
Georgia	3 (0.1)	1 (0.2)	2 (0.2)	Texas	104 (6.6)	65 (10.2)	39 (4.1)
Illinois	1 (0.1)	0 (0.0)	1 (0.1)	Virginia	1 (0.1)	1 (0.2)	0 (0.0)
Indiana	1 (0.1)	0 (0.0)	1 (0.1)	Washington	1 (0.1)	1 (0.2)	0 (0.0)
Kansas	1 (0.1)	0 (0.0)	1 (0.1)	Wisconsin	2 (0.1)	1 (0.2)	1 (0.1)
Kentucky	2 (0.1)	1 (0.2)	1 (0.1)	Wyoming	1 (0.1)	0 (0.0)	1 (0.1)
Maryland	2 (0.1)	0 (0.0)	2 (0.2)	Outside the U.S.	5 (0.3)	1 (0.2)	4 (0.4)

Table C.8
Frequency Table for Description of Outdoor Recreational Skills

Which of the following best describes your skills at nonmotorized outdoor recreational activities?

	Combined Sample		Tensas Lottery Sample		General Population Sample	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Beginner	181	11.9	63	10.1	118	13.1
Intermediate	391	25.6	202	32.4	189	20.9
Advanced	203	13.3	127	20.4	76	8.4
Expert	22	1.4	10	1.6	12	1.3

Table C.9
Frequency Tables for Respondent's Description of Non-motorized Outdoor Recreational Activities Location

Which of the following best describes the area in which you took part in outdoor recreational activities besides hunting and fishing?

	Combined Sample		Tensas Lottery Sample		General Population Sample	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Land that I own	208	13.2	112	17.6	96	10.2
Land that I lease	192	12.2	46	4.9	146	20.4
Land that a friend or relative owns	291	18.4	160	25.1	131	13.9
State managed land or parks	504	31.9	269	42.2	235	24.9
Federally managed land or parks	324	20.5	207	32.4	117	12.4
Coastal marshes	124	7.8	54	8.5	70	7.4
Lakes or reservoirs	748	19.7	170	26.6	142	15.1
Rivers, streams, or bayous	417	26.4	227	35.6	190	20.2
Ocean or beach	207	13.1	74	11.6	133	14.1
Other	36	2.3	19	61.4	17	1.8

Table C.10
Frequency Table for Participants' Non-Motorized Outdoor Recreation Site by State

In what state or states did you take part in these activities during 1996?

State	Combined Sample	Tensas Lottery Sample	General Population Sample	State	Combined Sample	Tensas Lottery Sample	General Population Sample
	Frequency (Percent)				Frequency (Percent)		
Louisiana	748 (47.3)	392 (61.4)	356 (37.8)	Kentucky	2 (0.1)	0 (0.0)	2 (0.2)
Arkansas	96 (6.1)	47 (7.4)	49 (5.2)	Maryland	1 (0.1)	0 (0.0)	1 (0.1)
Mississippi	174 (11.0)	58 (9.1)	116 (12.3)	Missouri	6 (0.4)	4 (0.6)	2 (0.2)
Alabama	36 (2.3)	8 (1.3)	28 (3.0)	Montana	1 (0.1)	1 (0.2)	0 (0.0)
Alaska	2 (0.1)	1 (0.2)	1 (0.1)	Nevada	2 (0.1)	1 (0.2)	1 (0.1)
Arizona	4 (0.3)	1 (0.2)	3 (0.3)	New Hampshire	1 (0.1)	0 (0.0)	1 (0.1)
California	6 (0.4)	0 (0.0)	6 (0.6)	New Jersey	1 (0.1)	0 (0.0)	1 (0.1)
Colorado	15 (0.9)	5 (0.8)	10 (1.1)	New Mexico	3 (0.2)	0 (0.0)	3 (0.3)
Connecticut	1 (0.1)	0 (0.0)	1 (0.1)	North Carolina	14 (0.9)	2 (0.3)	12 (1.3)
Delaware	1 (0.1)	0 (0.0)	1 (0.1)	North Dakota	2 (0.1)	1 (0.2)	1 (0.1)
Florida	72 (4.6)	21 (3.3)	51 (5.4)	Oklahoma	2 (0.1)	2 (0.3)	0 (0.0)
Georgia	8 (0.5)	2 (0.3)	6 (0.6)	Oregon	1 (0.1)	1 (0.2)	0 (0.0)
Illinois	3 (0.2)	1 (0.2)	2 (0.2)	Pennsylvania	2 (0.1)	0 (0.0)	2 (0.2)
Kansas	4 (0.3)	0 (0.0)	4 (0.4)	Rhode Island	1 (0.1)	0 (0.0)	1 (0.1)

(table con'd)

In what state or states did you take part in these activities during 1996?							
State	Combined Sample	Tensas Lottery Sample	General Population Sample	State	Combined Sample	Tensas Lottery Sample	General Population Sample
	Frequency (Percent)				Frequency (Percent)		
South Carolina	3 (0.2)	2 (0.3)	1 (0.1)	Washington	1 (0.1)	1 (0.2)	0 (0.0)
Tennessee	18 (1.1)	2 (0.3)	16 (1.7)	West Virginia	1 (0.1)	0 (0.0)	1 (0.1)
Texas	73 (4.6)	34 (5.3)	39 (4.1)	Wyoming	3 (0.2)	2 (0.3)	1 (0.1)
Utah	3 (0.2)	0 (0.0)	3 (0.3)	Outside the U.S.	6 (0.4)	3 (0.5)	3 (0.3)

Table C.11
Frequency Tables for Respondent's Visitation to the Big Lake Wildlife Management Area

Did you visit the Big Lake Wildlife Management Area near Winnsboro, Louisiana during 1996?						
	Combined Sample		Tensas Lottery Sample		General Population Sample	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Yes	288	80.8	274	43.8	14	1.5
No	1245	18.7	349	55.8	896	97.8
I don't know	8	0.5	2	0.3	6	0.7

Table C.12
Frequency Tables for Respondent's Visitation to the Tensas River National Wildlife Refuge

Did you visit the Tensas River National Wildlife Refuge during 1996?						
	Combined Sample		Tensas Lottery Sample		General Population Sample	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Yes	501	32.2	473	74.8	28	3.0
No	1042	67.0	157	24.8	885	95.8
I don't know	13	0.8	2	0.3	11	1.2

Table C.13
Frequency Table for Respondent's Outdoor Recreational Activities by Visitors to the Tensas River National Wildlife Refuge

In what types of activities did you take part at the Tensas River National Wildlife Refuge during 1996?

	Combined Sample		Tensas Lottery Sample		General Population Sample	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Hunting	466	93.2	451	95.3	15	55.6
Fishing	77	15.4	74	15.6	3	10.7
Environmental Education	20	4.0	19	4.0	1	3.6
Bird Watching	43	8.6	37	7.8	6	21.4
Wildlife Watching	135	26.9	127	26.8	8	28.6
Outdoor Photography	33	6.6	32	6.8	1	3.6
Hiking	69	13.8	64	13.5	5	17.9
All Terrain Vehicle (A.T.V.) Use	220	43.9	212	44.8	8	28.6
Other	35	7.0	28	5.9	7	25.0

Table C.14
Frequency Table for the Importance of Selected Recreational Activities by Visitors to the Tensas River National Wildlife Refuge

Please indicate how important each of the public activities at the Tensas River NWR is to you.	Not Important At All	Not Very Important	Somewhat Important	Very Important
	Percent	Percent	Percent	Percent
Hunting				
Combined	0.8	0.4	7.1	91.7
Tensas	0.4	0.4	6.4	92.8
General	8.0	20.0	0.0	72.0
Fishing				
Combined	8.3	14.1	30.0	47.6
Tensas	8.1	22.7	30.3	46.9
General	12.5	4.2	25.0	58.3
Environmental Education				
Combined	8.3	9.3	33.0	49.4
Tensas	8.3	9.0	33.4	49.2
General	8.7	21.7	26.1	52.2
Bird Watching				
Combined	22.8	27.7	29.9	19.6
Tensas	22.9	29.2	29.4	18.5
General	20.8	4.2	37.5	37.5
Wildlife Watching				
Combined	6.4	8.0	35.2	50.5
Tensas	6.3	8.5	34.7	50.5
General	7.7	0.0	42.3	50.0

(table con'd)

Please indicate how important each of the public activities at the Tensas River NWR is to you.	Not Important At All	Not Very Important	Somewhat Important	Very Important
	Percent	Percent	Percent	Percent
Outdoor Photography				
Combined	21.3	24.8	32.8	21.1
Tensas	21.6	25.0	33.2	20.3
General	17.4	21.7	17.4	43.5
Hiking				
Combined	18.4	24.6	33.2	23.8
Tensas	18.5	24.7	34.1	22.7
General	17.4	21.7	17.4	43.5
A.T.V. Use				
Combined	15.4	10.1	23.1	51.4
Tensas	14.4	9.7	22.9	53.1
General	36.4	54.5	81.8	18.2

Table C.15
Frequency Tables for Respondents' Prioritization of Issues

Please indicate what type of priority you think should be given to the following issues.				
	Very High Priority	High Priority	Low Priority	Very Low Priority
	Percent	Percent	Percent	Percent
Improving the health care system				
Combined	55.8	33.6	8.4	2.2
Tensas	55.6	34.6	7.1	2.7
General	56.0	32.9	9.3	1.9
Cutting government spending				
Combined	61.9	30.1	6.5	1.4
Tensas	63.5	28.1	7.1	1.3
General	60.8	31.5	6.1	1.6
Lowering crime rates				
Combined	77.1	19.8	2.2	0.8
Tensas	76.3	19.9	2.4	1.4
General	77.7	19.8	2.1	0.4
Improving public education				
Combined	71.9	25.1	1.8	1.2
Tensas	74.0	23.9	0.6	1.5
General	70.4	26.0	2.6	1.0
Protecting the environment				
Combined	64.2	31.0	3.8	1.1
Tensas	74.8	22.0	2.1	1.1
General	56.8	37.2	4.9	1.1

Table C.16
Frequency Table for Respondents' Opinion on Current State of U.S. Environment

In your opinion, which of the following best describes the current state of the U.S. environment?

	Combined Sample		Tensas Lottery Sample		General Population Sample	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Improving a great deal	124	7.9	59	9.3	65	7.0
Improving somewhat	732	46.9	280	44.2	452	48.8
Staying the same	284	18.2	102	16.1	182	19.6
Getting somewhat worse	340	21.8	155	24.5	185	20.0
Getting a great deal worse	80	5.1	37	5.8	43	4.6

Table C.17
Frequency Tables for Respondents' Prioritization of Environmental Issues

Thinking specifically of environmental issues, how important is each of the following issues?

	Not Important At All	Not Very Important	Somewhat Important	Very Important
	Percent	Percent	Percent	Percent
Air quality in the U.S.				
Combined	0.5	1.7	16.4	81.4
Tensas	0.3	1.3	14.8	83.6
General	0.5	1.9	17.5	80.0
Water quality in the U.S.				
Combined	0.3	0.9	9.2	89.6
Tensas	0.2	0.6	6.8	92.4
General	0.4	1.1	10.8	87.7
Toxic waste in the U.S.				
Combined	0.7	1.0	14.3	83.9
Tensas	0.5	0.8	10.9	87.8
General	0.9	1.2	16.6	81.3
Acid Rain in the U.S.				
Combined	1.7	8.5	37.5	52.3
Tensas	1.8	6.9	34.1	57.2
General	1.7	9.7	39.6	48.8
Global climate change				
Combined	5.7	14.5	37.3	42.5
Tensas	5.0	12.6	35.4	47.0
General	6.2	15.8	38.7	39.3

(table con'd)

Thinking specifically of environmental issues, how important is each of the following issues?				
	Not Important At All	Not Very Important	Somewhat Important	Very Important
	Percent	Percent	Percent	Percent
Loss of rain forests				
Combined	1.6	6.1	27.9	64.3
Tensas	1.0	4.5	24.6	69.9
General	2.1	7.2	30.2	60.5
Over-consumption of resources in the U.S.				
Combined	1.8	5.9	32.1	60.3
Tensas	1.1	3.6	32.1	64.1
General	2.2	7.5	32.7	57.6
The rate at which land is being developed and places in nature being lost				
Combined	1.3	4.1	24.3	70.3
Tensas	0.8	1.1	16.7	81.4
General	1.6	6.2	29.5.	62.7
The rate at which plant and animal species are becoming extinct.				
Combined	1.9	7.4	30.5	60.2
Tensas	1.4	4.2	24.4	70.0
General	2.3	9.5	34.6	53.6

Table C.18
Frequency Table for Respondents' Knowledge with the Term "Biodiversity"

Have you previously heard of the word biodiversity?

	Combined Sample		Tensas Lottery Sample		General Population Sample	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Yes	573	36.8	253	40.2	320	34.4
No	878	56.2	334	53.1	544	58.5
I don't know	108	6.9	42	6.7	66	7.1

Table C.19
Frequency Table for Respondents' Knowledge of Rate of Extinctions

In your opinion, which term best describes what is happening to the number of plant and animal species in the world?

	Combined Sample		Tensas Lottery Sample		General Population Sample	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Increasing	86	5.5	56	8.8	30	3.2
Decreasing	1073	68.2	416	65.3	657	70.2
Staying the same	176	11.2	84	13.2	92	9.8
I don't know	237	15.1	81	12.7	156	16.7

Table C.20
Frequency Table for Respondents' Knowledge of Cause of Extinctions

What do you think is the main reason plant and animal species become extinct?

	Combined Sample		Tensas Lottery Sample		General Population Sample	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Mostly natural causes	70	4.5	24	3.8	46	4.9
Mostly human actions	855	54.4	363	57.1	492	52.5
Natural causes and human actions, about equally	552	35.1	232	36.5	320	34.2
I don't know	96	6.1	17	2.7	78	8.3

Table C.21
Frequency Table for Questionnaire Return Rate According to Willingness-to-Pay Amount

Would you be willing to pay $X from your household budget into a voluntary fund **each year** to restore habitat for the variety of plant and animal species in the Tensas River basin **just for the knowledge that they exist?**

	Combined Sample		Tensas Lottery Sample		General Population Sample	
Questionairre Dollar Amount	Frequency	Percent	Frequency	Percent	Frequency	Percent
$1	244	15.4	88	13.8	156	16.6
$5	240	15.2	98	15.4	142	15.1
$10	223	14.1	87	13.6	136	14.4
$25	215	13.6	87	13.6	128	13.6
$50	210	13.3	93	14.6	117	12.4
$100	239	15.1	99	15.5	140	14.9
$150	208	13.2	86	13.5	122	13.0

Table C.21A
Frequency Table for Respondents' Willingness-to-Pay

Would you be willing to pay $X from your household budget into a voluntary fund each year to restore habitat for the variety of plant and animal species in the Tensas River basin just for the knowledge that they exist?

	Combined Sample		Tensas Lottery Sample		General Population Sample	
Questionnaire Dollar Amount	Frequency	Percent	Frequency	Percent	Frequency	Percent
$1						
Yes	158	64.8	72	81.8	117	55.1
No	40	16.4	9	10.2	31	19.9
I am not certain	46	18.9	7	8.0	39	25.0
$5						
Yes	117	49.4	59	60.8	58	41.4
No	67	28.3	24	24.7	43	30.7
I am not certain	53	22.4	14	14.4	39	27.9
$10						
Yes	89	40.1	54	62.8	35	35.7
No	77	34.7	13	15.1	64	47.1
I am not certain	56	25.2	19	22.1	37	27.2
$25						
Yes	57	27.0	37	43.5	20	15.9
No	103	48.8	28	32.9	75	59.5
I am not certain	51	24.2	20	23.5	31	24.6
$50						
Yes	43	20.6	24	25.8	19	16.4
No	106	50.7	34	36.6	72	62.1
I am not certain	60	28.7	35	37.6	25	21.6

(table con'd)

Would you be willing to pay $X from your household budget into a voluntary fund each year to restore habitat for the variety of plant and animal species in the Tensas River basin just for the knowledge that they exist?

Questionnaire Dollar Amount	Combined Sample		Tensas Lottery Sample		General Population Sample	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
$100						
Yes	30	12.7	17	17.2	13	9.4
No	138	58.2	48	48.5	90	65.2
I am not certain	69	29.1	34	34.3	35	25.4
$150						
Yes	16	7.7	7	8.1	9	7.4
No	140	67.3	54	62.8	86	70.5
I am not certain	52	25.0	25	29.1	27	22.1

Table C.22
Frequency Table for Respondents' Reasons for Negative Response to Willingness to Pay Question

If you answered NO to question 21, please mark the reason that best describes why you answered NO.

	Percent						
	Questionnaire Dollar Amounts						
	$1	$5	$10	$25	$50	$100	$150
It would be worth some smaller amount to me.							
Combined Sample	2.5	1.5	1.3	6.0	6.7	12.4	8.6
Tensas Lottery	0.0	0.0	0.0	3.6	6.1	21.3	9.4
General Population Sample	3.2	2.4	1.6	6.9	6.9	7.8	8.1
It would be worth nothing to me.							
Combined Sample	12.5	9.2	11.8	9.0	6.7	5.1	7.2
Tensas Lottery	0.0	0.0	15.4	0.0	0.0	6.4	3.8
General Population Sample	16.1	14.3	11.1	12.5	9.7	4.4	9.3
People should not have to pay for the restoration or conservation of wild habitat or ecosystems.							
Combined Sample	27.5	33.8	18.4	23.0	22.9	16.1	20.1
Tensas Lottery	22.2	21.7	15.4	14.3	24.2	12.8	26.4
General Population Sample	29.0	40.5	19.0	26.4	22.2	17.8	16.3
I cannot afford to pay for the restoration or conservation of wild habitat.							
Combined Sample	17.5	13.8	28.9	20.0	27.6	35.0	37.4
Tensas Lottery	22.2	17.4	0.0	10.7	30.3	21.3	30.2
General Population Sample	16.1	11.9	34.9	23.6	26.4	42.2	41.9
I object to the question.							
Combined Sample	12.0	12.3	15.8	10.0	8.6	9.5	7.9
Tensas Lottery	11.1	17.4	38.5	10.7	9.1	4.2	9.4
General Population Sample	16.1	7.1	14.3	11.1	8.3	12.2	7.0

(table con'd)

If you answered NO to question 21, please mark the reason that best describes why you answered NO							
.	Percent						
	Questionnaire Dollar Amounts						
	$1	$5	$10	$25	$50	$100	$150
Other (Protest).							
Combined Sample	20.0	24.6	15.8	27.0	24.8	16.8	18.0
Tensas Lottery	33.3	39.1	30.8	53.6	27.3	23.4	20.8
General Population Sample	16.1	16.7	12.7	16.7	23.6	13.3	16.3
Other (Non-protest)							
Combined Sample	5.0	4.6	7.9	4.0	2.9	5.1	0.7
Tensas Lottery	11.1	4.3	15.4	7.1	3.0	10.6	0.0
General Population Sample	3.2	4.8	6.3	2.8	2.8	2.2	1.2

Table C.23
Frequency Table for Respondents' Reasons for Positive Responses to Willingness-to-Pay Question

If you answered YES question 21, please mark the reason that best describes why you answered YES.

	Percent						
	Questionnaire Dollar Amounts						
	$1	$5	$10	$25	$50	$100	$150
It would be worth that much to me to increase the habitat to increase the number of species of plants and animals.							
Combined Sample	66.0	62.1	65.5	75.4	66.7	63.3	43.8
Tensas Lottery	81.4	69.0	65.4	81.1	73.9	76.5	42.9
General Population Sample	53.5	55.2	65.7	65.0	57.9	92.3	44.4
That is all I have available to give at this time.							
Combined Sample	3.8	1.7	3.4	1.8	2.4	6.7	0.0
Tensas Lottery	0.0	0.0	0.0	2.7	0.0	5.9	0.0
General Population Sample	7.0	3.4	8.6	0.0	5.3	7.7	0.0
It makes me feel good to give to worthy causes.							
Combined Sample	3.2	4.3	4.6	0.0	0.0	0.0	0.0
Tensas Lottery	5.7	3.4	7.7	0.0	0.0	0.0	0.0
General Population Sample	1.2	5.2	0.0	0.0	0.0	0.0	0.0
People should help preserve wild habitat and ecosystems, and I feel this is my "fair share."							
Combined Sample	26.9	31.9	26.4	21.1	31.0	30.0	56.3
Tensas Lottery	12.9	27.5	26.9	13.5	26.1	17.6	56.9
General Population Sample	38.4	36.2	25.7	35.0	36.8	46.2	55.6

(table con'd)

If you answered YES question 21, please mark the reason that best describes why you answered YES.

	Percent						
	Questionnaire Dollar Amounts						
	$1	$5	$10	$25	$50	$100	$150
This is the amount I give to all causes that I believe in.							
Combined Sample	0.0	0.0	0.0	1.8	0.0	0.0	0.0
Tensas Lottery	0.0	0.0	0.0	2.7	0.0	0.0	0.0
General Population Sample	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table C.24
Frequency Table for the New Ecological Paradigm Scale Statements

New Ecological Paradigm					
	Percent				
	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
We are approaching the limit of the number of people the earth can support.					
Combined Sample	16.0	25.0	33.1	20.5	5.4
Tensas Lottery	18.6	28.1	32.4	16.9	4.0
General Population Sample	14.1	22.9	33.5	23.0	6.5
Humans have the right to modify the natural environment to suit their needs.					
Combined Sample	3.9	22.9	20.2	36.4	16.6
Tensas Lottery	3.3	17.5	20.3	40.8	18.0
General Population Sample	4.3	26.6	20.2	33.3	15.6
When humans interfere with nature it often produces disastrous consequences.					
Combined Sample	27.5	48.0	11.7	11.1	1.7
Tensas Lottery	29.0	50.7	9.4	9.0	1.9
General Population Sample	26.6	46.1	13.2	12.6	1.5
Human ingenuity will ensure that we do not make the earth unlivable.					
Combined Sample	6.0	25.8	38.5	22.0	1.7
Tensas Lottery	4.7	23.1	39.9	24.1	8.2
General Population Sample	6.9	27.6	37.5	20.6	7.3

(table con'd)

New Ecological Paradigm					
	Percent				
	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
Humans are severely abusing the environment.					
Combined Sample	25.8	47.7	12.0	12.8	1.7
Tensas Lottery	27.8	50.1	10.2	10.6	1.3
General Population Sample	24.4	46.1	13.2	14.3	2.0
The earth has plenty of natural resources if we just learn how to develop them.					
Combined Sample	19.9	53.9	14.9	9.2	2.1
Tensas Lottery	20.4	53.7	15.3	9.1	1.6
General Population Sample	19.6	54.1	14.6	9.2	2.5
Plants and animals have as much as humans to exist.					
Combined Sample	27.8	42.1	10.2	15.0	4.9
Tensas Lottery	30.2	41.8	10.3	12.9	4.8
General Population Sample	26.2	42.2	10.1	16.4	5.1
The balance of nature is strong enough to cope with the impacts of modern industrial nations.					
Combined Sample	2.8	11.5	26.9	40.0	18.8
Tensas Lottery	2.2	10.0	23.6	41.9	22.3
General Population Sample	3.2	12.6	29.1	38.6	16.4

(table con'd)

New Ecological Paradigm					
	Percent				
	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
Despite our special abilities, humans are still subject to the laws of nature.					
Combined Sample	24.4	65.8	7.0	2.3	0.4
Tensas Lottery	24.1	66.3	6.4	2.6	0.6
General Population Sample	24.6	65.5	7.5	2.2	0.2
The so-called "ecological crisis" facing mankind has been greatly exaggerated.					
Combined Sample	6.3	19.9	38.1	26.9	8.7
Tensas Lottery	5.1	19.6	39.9	28.7	6.7
General Population Sample	7.0	20.2	36.9	25.7	10.1
The earth is like a spaceship with very limited room and resources.					
Combined Sample	11.7	44.1	18.7	22.2	3.3
Tensas Lottery	10.5	48.3	16.1	21.4	3.7
General Population Sample	12.5	41.2	20.5	22.8	3.0
Humans are meant to rule over the rest of nature.					
Combined Sample	10.2	30.0	17.1	30.7	12.0
Tensas Lottery	10.2	27.6	15.6	33.3	13.2
General Population Sample	10.2	31.7	18.1	28.9	11.1

(table con'd)

New Ecological Paradigm

	Percent				
	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
The balance of nature is delicate and easily upset.					
Combined Sample	19.9	54.1	13.9	11.3	0.8
Tensas Lottery	22.4	55.2	11.8	9.7	1.0
General Population Sample	18.2	53.3	15.3	12.4	0.8
Humans will eventually learn enough about how nature works to be able to control it.					
Combined Sample	2.8	22.5	33.4	30.9	10.4
Tensas Lottery	2.2	17.6	32.1	34.9	13.2
General Population Sample	3.2	26.0	34.3	28.2	8.4
If things continue on their present course, we will soon experience a major ecological catastrophe.					
Combined Sample	14.4	29.1	37.2	15.8	3.5
Tensas Lottery	14.3	29.4	39.0	14.1	3.2
General Population Sample	14.5	28.8	36.0	16.9	3.7

Table C.25
Frequency Table for Respondents' Gender

What is your gender?

	Combined Sample		Tensas Lottery Sample		General Population Sample	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Male	1293	83.0	609	96.2	684	73.9
Female	266	17.0	24	3.8	242	26.1

Table C.26
Frequency Table for Respondents' Education Level

What is the highest level of education you have completed?

	Combined Sample		Tensas Lottery Sample		General Population Sample	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Some Grade School	40	2.6	8	1.3	32	3.4
Some High School	131	8.4	54	8.6	77	8.3
Completed High School	495	31.8	258	40.9	237	25.5
Some College	411	26.4	180	28.5	231	24.9
Completed College	313	20.1	99	15.7	214	23.1
Advanced Degree	169	10.8	32	5.1	137	14.8

Table C.27
Frequency Table for Respondents' Race or Ethnic Background

Which of the following best describes your racial or ethnic background?

	Combined Sample		Tensas Lottery Sample		General Population Sample	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
American Indian	28	1.8	16	2.5	12	1.3
Asian or Pacific Islander	6	0.4	0	0	6	0.7
Black (African American)	77	5.0	8	1.3	69	7.6
Hispanic	21	1.4	3	0.5	18	2.0
White (Caucasian)	1409	91.4	601	95.7	808	88.5

Table C.28
Frequency Table for Respondents' Place of Residence

Which of the following best describes your area of residence?

	Combined Sample		Tensas Lottery Sample		General Population Sample	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Farm or Open country	346	22.2	290	45.7	56	6.0
Towns under 10,000	282	18.1	122	19.2	160	17.3
Towns and Cities 10,000 to 50,000 people	393	25.2	119	18.8	274	29.6
Suburbs of city over 50,000	316	20.3	75	11.8	241	26.0
Central City of over 50,000	223	14.3	28	4.4	195	21.1

Table C.29
Frequency Table for Respondents' Income Level

Which of the following best describes your total household income for 1996?						
	Combined Sample		Tensas Lottery Sample		General Population Sample	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
LESS than $15,000	143	9.9	35	5.9	108	12.7
$15,000 to $24,999	212	14.7	82	13.7	130	15.3
$25,000 to $34,999	240	16.6	120	20.1	120	14.2
$35,000 to $49,999	305	21.1	140	23.4	165	19.5
$50,000 to $74,999	334	23.1	168	28.1	166	19.6
$75,000 to $99,999	113	7.8	32	5.4	81	9.6
Over $100,000	99	6.8	21	3.5	78	9.2

Table C.30
Summary Statistics for the Continuous Variables of the Lower Mississippi River Valley Plant and Wildlife Survey

Variable	Combined Sample	Tensas Lottery Sample	General Population Sample
Age			
Mean	46.6	39.9	51.2
Minimum	7.0	13.0	7.0
Maximum	93.0	79.0	93.0
Standard Deviation	15.5	11.9	15.9
Household Size			
Mean	2.92	3.2	2.69
Minimum	1	1	1
Maximum	9	8	9
Standard Deviation	1.33	1.25	1.32
Number of people under 18, residing in the household			
Mean	0.81	1.10	0.62
Minimum	0	0	0
Maximum	7	5	7
Standard Deviation	1.07	1.09	1.01

Vita

Jack Coburn Isaacs, the son of Jack and Mary Ellen Isaacs, was born in the Broward County Medical Center in Fort Lauderdale, Florida, at shortly before 2:30 p.m. on Thursday, April 18, 1968. Being a longtime Baltimore Orioles fan has taught him patience and endurance. After graduating from Saint Thomas Aquinas High School in 1986, he accepted a Selby Grant and attended the Florida State University in Tallahassee, Florida. He acquired a Bachelor of Science degree in economics in 1989. In 1991, he caught a few Cubs' games and finished his master's degree in economics at Northwestern University. He enrolled in the doctoral program in agricultural economics at Louisiana State University in 1994.

DOCTORAL EXAMINATION AND DISSERTATION REPORT

Candidate: Jack Coburn Isaacs

Major Field: Agricultural Economics

Title of Dissertation: A Conceptual and Empirical Approach for Valuing Biodiversity: An Estimate of the Benefits of Plant and Wildlife Habitat Preservation in the Tensas River Basin

Approved:

E. Jane Luzar
Major Professor and Chairman

John M Larkin
Dean of the Graduate School

EXAMINING COMMITTEE:

Roger G Hinson

Richard J. Kennedy

Hector Zapata

Date of Examination:

November 05, 1997

IMAGE EVALUATION TEST TARGET (QA-3)

150mm

6"

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